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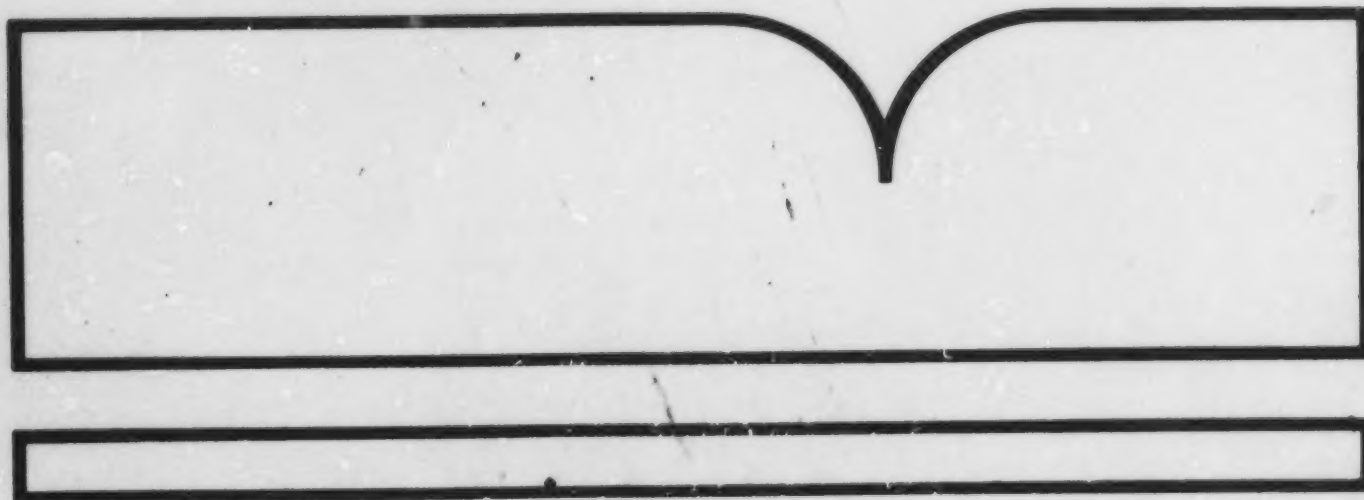
Report of the Preliminary Ground Water  
Contamination Investigation  
Lakewood, Washington, October - November 1981

Ecology and Environment, Inc., Seattle, WA

Prepared for

Environmental Protection Agency, Seattle, WA

Jan 81



U.S. Department of Commerce  
National Technical Information Service

**NTIS**

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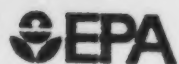
United States  
Environmental Protection  
Agency

Region 10  
1200 Sixth Avenue  
Seattle WA 98101

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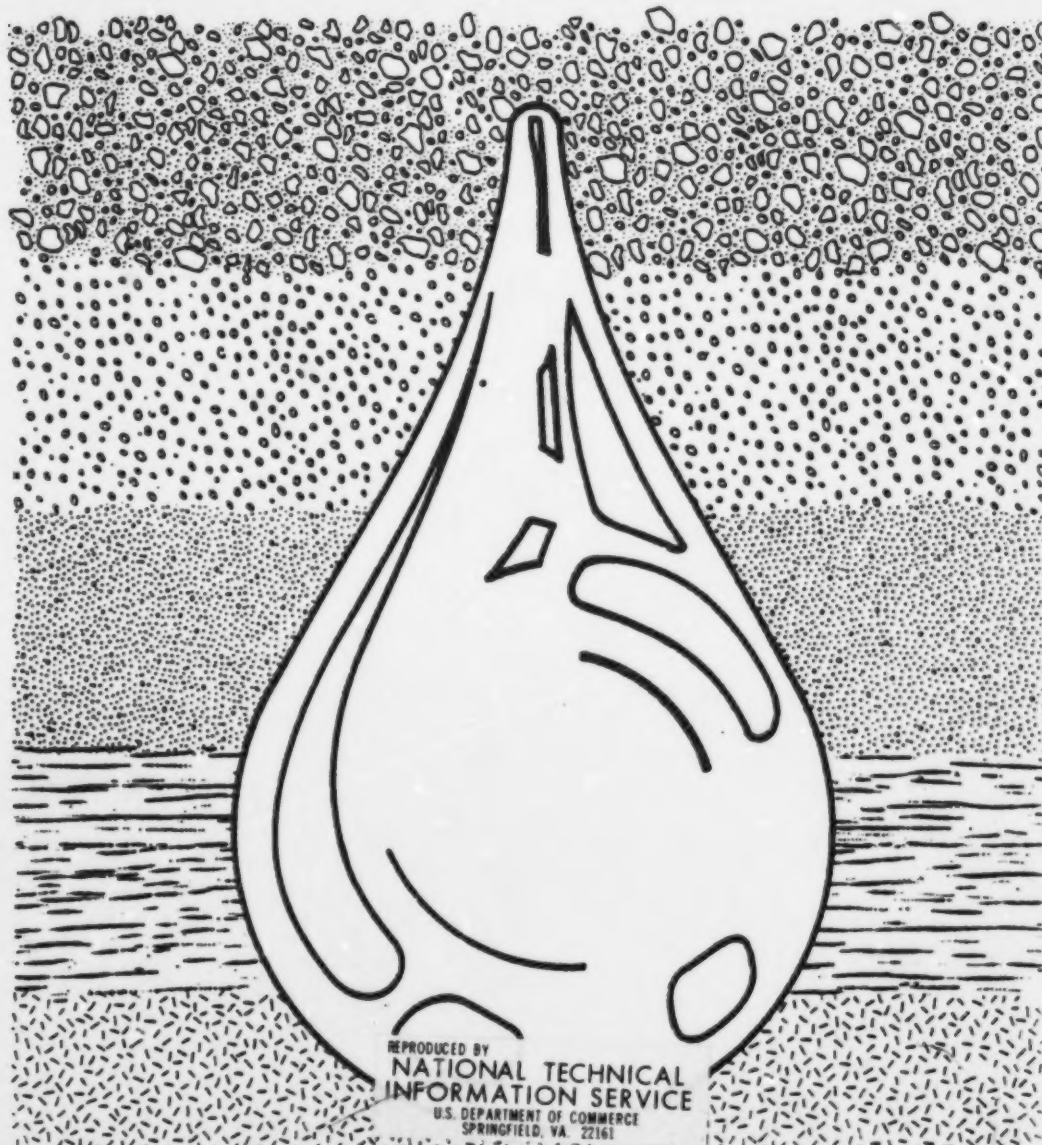
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January, 1981



# Report of the Preliminary Groundwater Contamination Investigation

Lakewood, Washington  
October—November, 1981



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SPRINGFIELD, VA. 22161

REPORT OF THE PRELIMINARY GROUND WATER CONTAMINATION  
INVESTIGATION, LAKEWOOD, WASHINGTON

OCTOBER - NOVEMBER 1981

By

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Fred Wolf

Kwasi Boateng

#### ABSTRACT

During the summer of 1980, organic solvents were discovered in the water produced by Lakewood Wells H-1 and H-2. Significantly higher concentrations were repeatedly detected in Well H-2. The drillers logs indicated that a tight hard pan (till) layer separated the production aquifer from the unconfined semi-perched aquifer above. The annular space at H-2 was found to have been filled with pea gravel and it was hypothesized that this could be a conduit for vertical migration of contaminant. This hypothesis would also account for the higher concentrations found in H-2. This preliminary investigation tests this hypothesis by the construction and monitoring of 10 observation wells. The study provides information which suggests hydrologic interconnections do exist between the semi-perched and the production aquifers, but does not suggest that the semi-perched zone is in fact the source of the organic solvents.

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## 1-0. Introduction

This investigation of ground water contamination occurring at the Lakewood (Washington) Water District's Ponders Well Field was initiated to obtain more detailed hydrogeologic data concerning the site. Earlier sampling at this location has shown strong evidence that both production wells, H-1 and H-2 are contaminated by Trichloroethylene, Tetrachloroethylene and 1, 2 (trans) Dichloroethylene. (Littler et.al 1981). An examination of the "as constructed" well logs from the two production wells revealed that the annular space of H-2 had been filled with highly porous gravel pack having no cement seal to prevent vertical migration of contaminants from the surface. The logs also showed the occurrence of a confining layer of till at about 25-30 ft. from the surface. It was hypothesized that this till could act as a confining layer creating a perched water table. If grossely contaminated, such an aquifer could be the source of contamination reaching the deeper aquifer downward through the annular gravel pack. The concentrations of the organics were higher in H-2 than H-1 which reenforced this hypothesis.

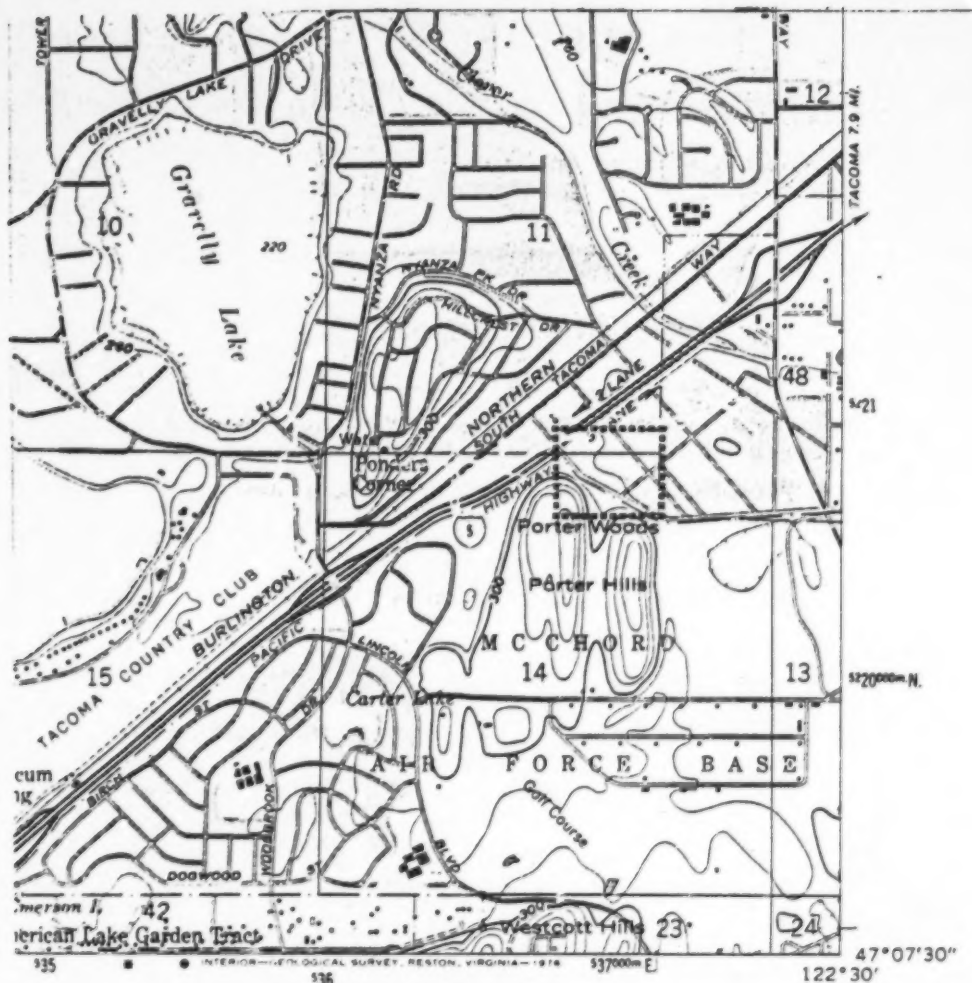
The purpose of this study was to probe the upper, perched aquifer to attempt to define the direction of movement and levels of contaminants present. If possible, a direction to the source area of the contaminants would be obtained. A network of shallow observation wells using low cost, but adequate levels of technology and construction were installed. Their siting was "interactive" based on field data and chemical information obtained from the Century Systems Model 128 Organic Vapor Analyzer (OVA-128) gas chromatograph. The physical installation of wells occurred during the first half of October, 1981, and the gathering of samples and data from October to January, 1982.

This project was carried out under the direction of the Environmental Services Division, U.S. EPA, Region 10 with supporting professional services and contracting support from the Field Investigation Team, Region 10, Ecology and Environment, Inc., under TDD 10-810803.

## 2.0. Physical Description

### 2.1 Location

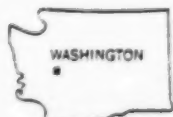
The Lakewood Water District contaminated wells are located within 200 feet N.E. of the intersection of I-5 and New York Ave. in Lakewood, Pierce County, Washington. The site is also located at N.W. 1/2 of the N.E. 1/4 of Section 14, Township 19N, Range 2E, and may also be located at Longitude 47° 08'30"N and Latitude 122° 31'15" W. The site is shown in Figure 1.



#### ROAD CLASSIFICATION

Heavy-duty ————— Light-duty —————  
 Medium-duty ————— Unimproved dirt .....

○ Interstate Route



QUADRANGLE LOCATION

#### STEILACOOM, WASH.

NE/4 ANDERSON ISLAND 15' QUADRANGLE  
 N4707 5—W12230/7.5

1959  
 PHOTOREVISED 1968 AND 1973  
 AMS 1478 II NE—SERIES V891

Figure 1  
 Location of Lakewood Study Area

## 2.2 Climate and Water Budget

The Lakewood-Tacoma general area has a temperate maritime climate with cool wet winters and warm dry summers. There is a marked deficit of actual transpiration over potential transpiration during the summer so that May-October are water deficit months, and November-April have excess precipitation.

Average annual precipitation for the area from 1945 to 1980 is 39.19 inches. Mean lake evaporation is about 23 inches per year (DOE 1981), leaving approximately 16 inches to infiltrate or run-off the site. The maximum 2-year precipitation expected in 24-hour period is 2 inches (Miller, et. al., 1973).

## 2.3 General Geology

The Lakewood-Tacoma general area is underlain by a great thickness of semiconsolidated and unconsolidated materials laid down in lakes or by streams during recent, Pleistocene and late tertiary time (Griffin, Sceva, et. al., 1962). These sediments include clay, silt, sand, and gravels, glacial till and peat. Water-bearing characteristics of the general area differ from place to place depending upon the rock type. The areas underlain by outwash sand and gravel deposits are the most productive aquifers, while in the till-capped areas, where permeability is low, aquifers are generally not productive and yield only small amounts of water to wells.

## 2.4 Site Geology

The study area is underlain by sand and gravels (see well logs), deposited by meltwater streams that flowed westward across the general area during the Vashon glaciation in the late Pleistocene. These outwash deposits are highly permeable and yield large quantities of water. One of the study wells, H-1 yields more than 2,000 gpm. with specific capacity of about 35 gpm. per foot of drawdown. (Griffin, Sceva, et. al., 1962).

Ground water was encountered between 20'-35' below ground elevation in all the observation wells.

## 3.0 Methodology

### 3.1 Description of Methodology and Drilling Site Selection

Drilling sites were preselected by the investigators allowing adequate time to obtain permission to drill, and to ensure the location could be reached by the rig. A standardized permission form was developed and is presented in the appendix. A total of 17 potential drilling sites were located with permission for

access and drilling obtained. Because the drilling program was interactive, individual sites selected for drilling based on field judgement and OVA data; each well site was chosen on the basis of information gathered in preceeding wells. The flexibility inherent in this approach permitted more data to be obtained using fewer drill sites. A map showing observation well locations is presented in Figure 2.

### 3.2 Well Construction

The observation wells were excavated to an average depth of 35 feet utilizing a truck-mounted hollow-stem auger drill rig (Mobile Drill D-61), to about 10 feet below the water table. The internal diameter of the auger was 4-inches.

A 2-1/2-inch ID ungalvanized steel casing (black iron pipe), was then installed. The perforated section of the casing was 10 feet (except observation wells #1 and 2 which were 20 and 15 feet long respectively). Since the formation material was coarse, it was not necessary to place gravel pack around the "screen" to serve as a filter media. Figures 3 and 4 show the slot being "cut" by torch and the finished slotted screen

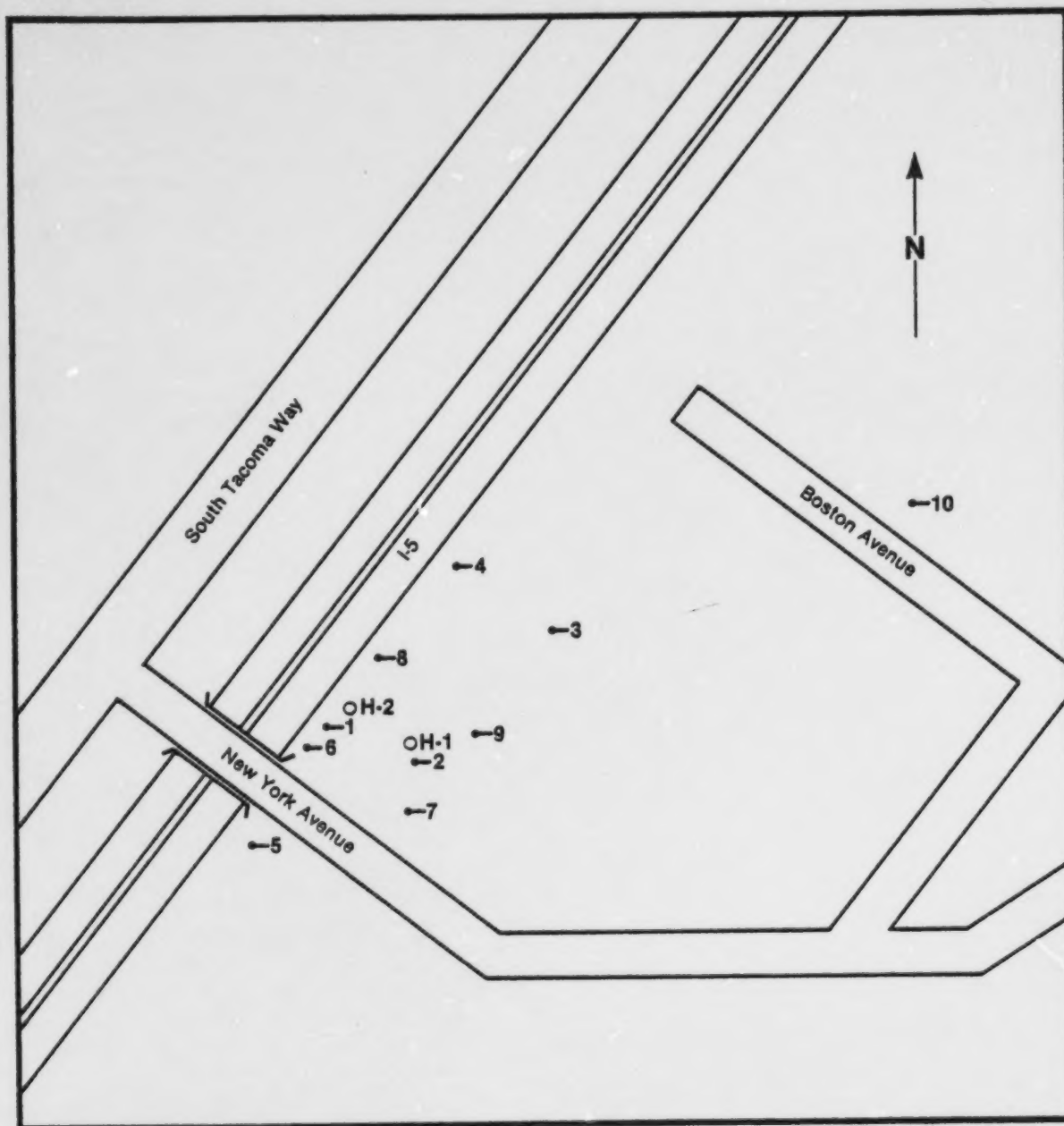
The annular space from the top of the screen (perforations) to 6 feet below ground surface was backfilled with drill cuttings. The annular space from the depth of 6 feet to ground surface was filled with a mixture of bentonite and fine sand in a ratio of one portion of fine sand and one portion bentonite in accordance of Washington State Department of Ecology (DOE) specifications. Details of well construction are illustrated in Figure 5.

### 3.3 Well Development

The completed wells were developed with compressed air to insure their utility as monitoring wells. This was done in a manner that did not cause any undue disturbance of the strata above the water table nor disturb the seal effected around the well casing and thereby reduce the sanitary protection. The development of the wells continued until the water pumped from the wells was clear and free of sand. This usually took 1-1/2 to 2 hours per well.

### 3.4 Pump Test

A pump test to establish the existance of the confining layer or significant difference in vertical permeability at the well field location was carried-out on 5 November 1981. The test was carried-out by pumping H-1 and H-2 for one hour each, while measuring drawdown in the pumping wells and water level changes in the observation wells. Measurements were carried out by two



\*Not Drawn to Scale

**Well Location Map\***  
Lakewood Washington

- Lakewood Water District Production Well
- Observation Well Installed by EPA

Figure 2

# Observation Well Construction\* Lakewood Project

\*Not Drawn to Scale

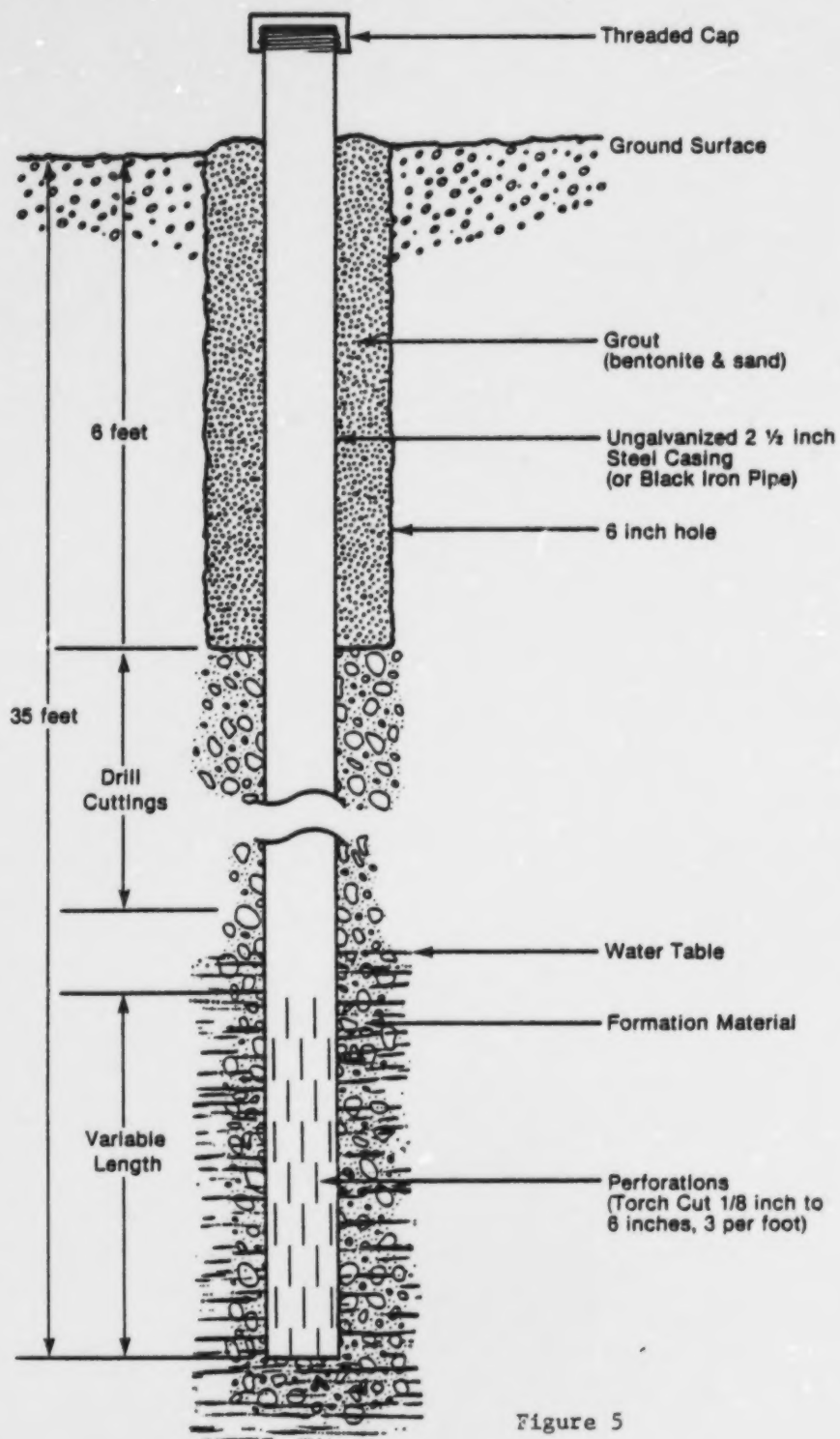
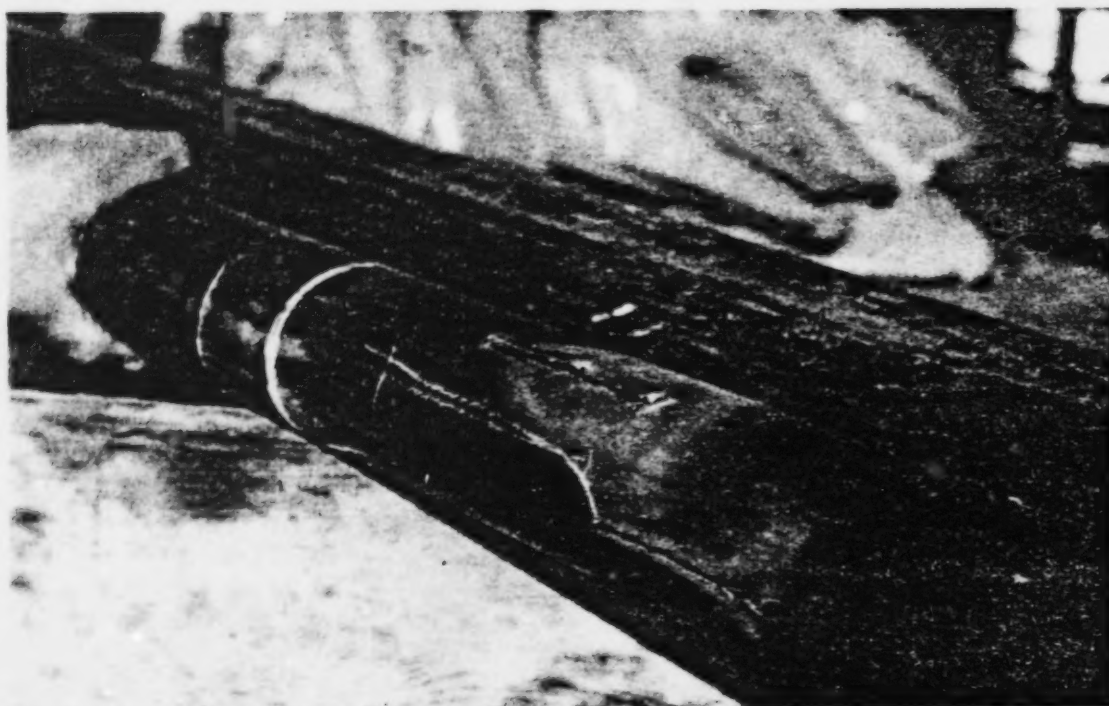


Figure 5



Driller's assistant cutting slots using a torch.



Torch-cut slots in black iron casing.

Figures 6 and 7

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teams of two people, with one team using electric tape and the other, steel tape. Well H-1 was pumped from 1149 to 1249 at a flow rate initially of 1250 gallons per minute, H-2 was similarly pumped for one hour, 1400 to 1500, at an initial flow of 1000 gallons per minute.

Water level elevations are presented in Table 1 and their curves are presented in Figures 8 through 19. During the pump test, water samples were obtained from the discharge pipe at the on-site discharge pit adjacent to H-2. The samples were taken at approximately 10 minute intervals and analyzed for tetrachloroethylene, trichloroethylene and 1, 2 (trans) Dichloroethylene.

### 3.5 Equipment Decontamination

The Lakewood project required us to use equipment decontamination procedures to insure that trace levels of volatile organic compounds were not the result of cross-contamination between drill sites nor resulting from sources outside the scope of the project area. Outside sources of contamination could include drilling water, contaminated truck surfaces used to haul auger sections or equipment in contact with contaminated surfaces. The drilling contractor was required to provide 2 complete 50 foot strings of auger. This permitted one string to be in use while the other was being cleaned and decontaminated off site. Prior to arrival on-site, the drill rig was steam cleaned. One technician and a driller's helper were responsible for operating the off-site decontamination station. Located at the Lakewood Water District's equipment and storage area, the station also served as a water source for the rig, where pre-analyzed water was available in adequate supply. A steam cleaner was obtained by the contractor for this project. The tank of this cleaner was scrubbed with Alconox and water and thoroughly rinsed before it was used. The water tank on the rig was similarly rinsed followed by steam cleaning.

Equipment decontamination during the drilling phase occurred as follows:

1. The truck carrying the augers and equipment was unloaded at the decontamination site, then scrubbed with Alconox and water followed by steam cleaning.
2. All drilling equipment and tools were scrubbed with Alconox and steam cleaned in the same manner and reloaded onto the truck without being set on the ground.
3. Since cleaning was carried out on a paved surface, drainage was controlled and directed to the sewer system.

Equipment used in the project was periodically checked by both the OVA-128 and HNU Vapor detector systems. No detection of organic vapors on tools or auger sections decontaminated by this procedure was observed.

### 3.6 Organic Vapor Analyzer (OVA)

A Century Systems Organic Vapor Analyzer (OVA) Model 128 was used to detect and monitor the presence of organic vapor during and after well installation. A twofold method was used. The survey mode was used to "sniff" the wells during drilling to determine if organic vapors were encountered. The G.C. mode was used to detect the type of organic compounds in the soil and water samples in the field (see appendix). HNU Model 101 Photoionization Analyzer was used to screen methane. Figures 6 and 7 illustrate the use of the HNU and the OVA to assess ambient vapor levels around the auger during drilling.

### 3.7 Survey

Elevations of the top of the well casings were surveyed to a common datum. This was necessary to determine the direction of ground water flow at the site.

The survey datum was an artificial plane 100 feet below the top of the cement monument located in the well house at H-1.

## 4.0 Sampling Program

A total of ten observation wells and two production wells were sampled.

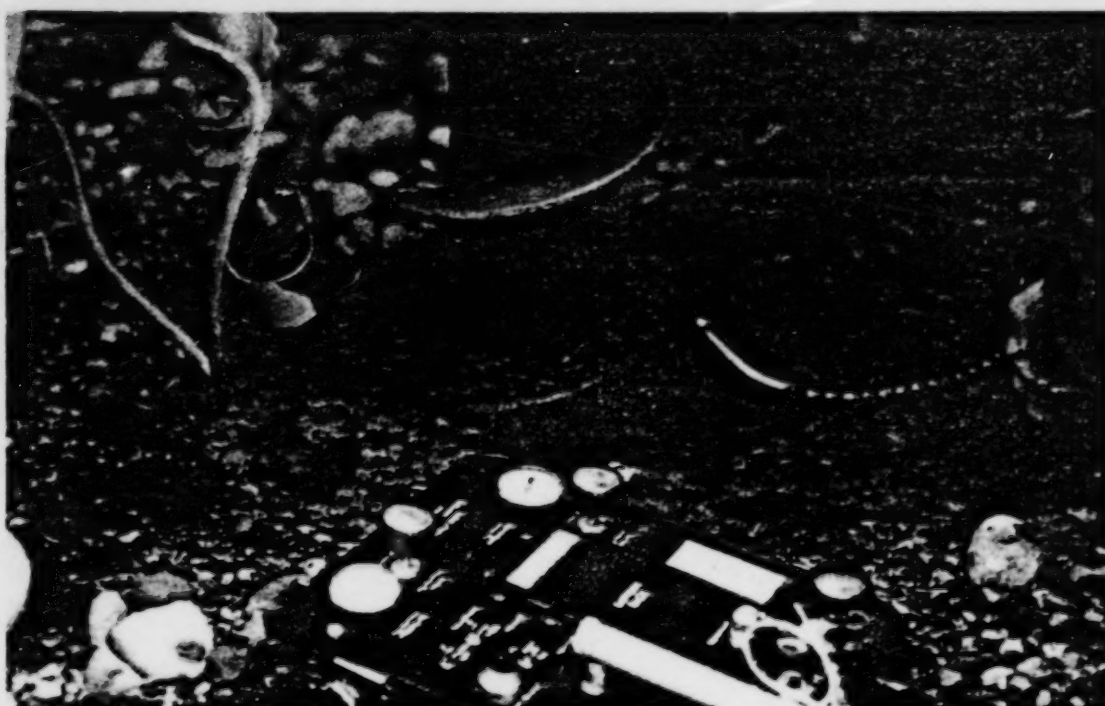
### 4.1 Observation Wells

At least three to five times the volume of water originally standing in the well was bailed out and the wells allowed to recharge before sampling. Samples were collected with a 1" stainless steel bailer lowered by a stainless steel wire. The bailer was cleaned with acetone, methylene chloride and dried with air before sampling each well.

All sampling containers, the bailer and the sampler's gloves were rinsed two times with the media to be sampled. The gloves were changed between sampling each well to eliminate cross-contamination. The outside of the containers were rinsed with distilled water before the containers were placed in the ice chest.

### 4.2 Production Wells

Samples were collected from the production wells H-1 and H-2 with 1" stainless steel bailer.



OVA-128 and H-NU instruments being used to measure vapor levels during augering.



Direct read-out of vapor levels using the OVA-128.

Figures 8 and 9

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#### 4.3 Analytical Requirements

All samples obtained from the observation wells were analyzed by the EPA Region X Laboratory for heavy metals, pesticides, acid extractible, base/neutral extractible and volatiles on the priority pollutants list. The production wells were analyzed for Trichloroethylene, Tetrachloroethylene and 1, 2 (trans) - Dichloroethene. All the wells except H-1 were analyzed for hardness, specific conductance, alkalinity, total dissolved solids, pH, SO<sub>4</sub> and Cl. A list of priority pollutants analyzed during this study is provided in Table 1.

The following containers were used:

|                                     |                                                |
|-------------------------------------|------------------------------------------------|
| Extractable Organics                | Two 1-gal. glass jars with teflon-lined lids.  |
| Volatile Organics                   | Two 40-ml. vials with teflon-lined lids.       |
| Pesticides                          | One 1/2 gal. glass jar with teflon-lined lids. |
| Heavy Metals and General Parameters | One 1-qt. polyethylene cubitainer.             |

#### 4.4 Sampling Documentations

The sampling procedures were documented in a field log book. Samples were shipped to EPA Region X Laboratory, and were accompanied by a Field Sample Data Sheet, an Analysis Requirement Sheet and a white copy of the Chain-of-Custody Record. These forms were sealed in a ziplock plastic bag. Each container was labeled with a sample number. A sample identification tag was tied around the container. The ice chest containing the samples was sealed with a Chain-of-Custody Seal before shipment in accordance with EPA procedures (MEIS, 1980).

#### 4.5 Quality Assurance

Quality Assurance was maintained by use of analytical blanks, field transfer blanks and appropriate media samples as described in section 3.5. All samples shipped to the laboratory were accompanied by appropriate pre-analyzed organic-free water blanks, in containers of the type used for the environmental samples and/or field transfer blanks. Field transfer blanks were used to establish that trace levels of organic compounds in environmental samples did not result from field procedures. All analytical data obtained in this study has been reviewed by the Environmental Services Division for quality assurance acceptability.

Table 1

Priority Pollutant Analyses Request  
for Lakewood Observation Wells

METALS

ANTIMONY  
ARSENIC  
BERYLLIUM  
CADMIUM  
CHROMIUM  
COPPER  
LEAD  
MERCURY  
NICKEL  
SELENIUM  
SILVER  
THALLIUM  
ZINC

PESTICIDES

ALDRIN  
CHLORDANE  
DIELDRIN  
4,4'DDT  
4,4'DDE  
4,4'DDD  
ALPHA ENDSULFAN  
BETA ENDSULFAN  
ENDOSULFAN SULFATE  
EMULIN  
ENDRIN ALDEHYDE  
HEPTACHLOR  
HEPTACHLOR EPOXIDE  
ALPHA BHC  
BETA BHC  
GAMMA BHC (LINDANE)  
DELTA BHC  
TOXAPHENE  
PCB 1016  
PCB 1221  
PCB 1232  
PCB 1242  
PCB 1248  
PCB 1254  
PCB 1260

BASE/NEUTRAL EXTRACTIBLES

ACENAPHTHENE  
BENZIDINE  
1,2,4-TRICHLOROBENZENE  
HEXACHLOROBENZENE  
HEXACHLOROETHANE  
BIS(2-CHLOROETHYL) ETHER  
2-CHLORONAPHTHALENE  
1,2-DICHLOROBENZENE  
1,3-DICHLOROBENZENE  
1,4-DICHLOROBENZENE  
3,3-DICHLOROBENZIDINE  
2,4-DINITROTOLUENE  
2,6-DINITROTOLUENE  
1,2-DIPHENYLHYDRAZINE  
FLUORANTHENE  
4-CHLOROPHENYL PHENYL ETHER  
4-BROMOPHENYL PHENYL ETHER  
BIS(2-CHLOROISOPROPYL) ETHER  
BIS(2-CHLOROETHOXY) METHANE  
HEXACHLOROBUTADIENE  
HEXACHLOROCYCLOPENTADIENE  
ISOPHORONE  
NAPHTHALENE  
NITROBENZENE  
N-NITROSODIMETHYLAMINE  
N-NITROSODI-N-PROPYLAMINE  
N-NITROSODIPHENYLAMINE  
BIS(2-ETHYLHEXYL) PHTHALATE  
N-BUTYL BENZYL PHTHALATE  
DI-N-BUTYL PHTHALATE  
DI-N-OCTYL PHTHALATE  
DIETHYL PHTHALATE  
DIMETHYL PHTHALATE  
BENZO(A)ANTHRACENE  
BENZO(A)PYRENE  
BENZO(B)FLUORANTHENE  
BENZO(K)FLUORANTHENE  
CHRYSENE  
ACENAPHTHYLENE  
ANTHRACENE  
BENZO (GHI) PERYLENE  
FLUORENE  
PHENANTHRENE  
1,2,5,6-DIBENZANTHRACENE  
INDENO(1,2,3-CD)PYRENE  
PYRENE  
TCDD

ACID EXTRACTIBLES

2,4,6-TRICHLOROPHENOL  
P-CHLORO-M-CRESOL  
2-CHLOROPHENOL  
2,4-DICHLOROPHENOL  
2,4-DIMETHYLPHENOL  
2-NITROPHENOL  
4-NITROPHENOL  
2,4-DINITROPHENOL  
4,6-DINITRO-O-CRESOL  
PENTACHLOROPHENOL  
PHENOL

VOLATILE ORGANICS

ACROLEIN  
ACRYLONITRILE  
BENZENE  
CARBON TETRACHLORIDE  
CHLOROBENZENE  
1,2-DICHLOROETHANE  
1,1,1-TRICHLOROETHANE  
1,1-DICHLOROETHANE  
1,1,2-TRICHLOROETHANE  
1,1,2,2-TETRACHLOROETHANE  
CHLOROETHANE  
CHLOROFORM  
1,1-DICHLOROETHYLENE  
1,2-TRANS-DICHLOROETHYLENE  
1,2-DICHLOROPROPANE  
CIS-1,3-DICHLOROPROPENE  
TRANS-1,3-DICHLOROPROPENE  
ETHYLBENZENE  
METHYLENE CHLORIDE  
METHYL CHLORIDE  
METHYL BROMIDE  
BROMOFORM  
BROMODICHLOROMETHANE  
TRICHLOROFLUOROMETHANE  
DICHLORODIFLUOROMETHANE  
DIBROMOCHLOROMETHANE  
TETRACHLOROETHYLENE  
TOLUENE  
TRICHLOROETHYLENE  
VINYL CHLORIDE  
BIS(CHLOROMETHYL) ETHER  
2-CHLOROETHYL VINYL ETHER

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#### 4.6 Site Safety Plan

A site safety plan was prepared by the Field Investigation Team, Region 10, Ecology and Environment, Inc. (FIT). This plan established the criteria for personnel protection as dictated by OVA-128 and HNU Model 101 analytical data. Since the level of organic vapors was expected to be very low in the respirable zone (breathing area of workers) respiratory protection was not required. Drillers were instructed to use disposable gloves, changing them on each well. The FIT provided a supply of MSA Ultra-twin respirators and Level D protective gear as a contingency. A copy of the Site Safety Plan is provided in the Appendix.

### 5.0 Results

#### 5.1 Summary

This study generated a generous amount of hydrogeological and chemical data. These samplings were highly specific in purpose and the results should be interpreted with this in mind. Numerous samples were obtained prior to and during the course of drilling. These samples were either of a quality assurance nature or were exploratory, such as samples of aquifer material. All such samples were analyzed by the EPA Manchester lab for the Volatile Organics listed with the 129 priority pollutants, none were detected. The study produced physical data in terms of lithologic logs, which are presented in the Appendix, water level elevations and fluctuations, dynamic levels of chemical constituents during pumpage in waters from H-1 and H-2 and extensive background water quality data from the observation wells.

#### 5.2 Data Obtained

The results of this study have been tabulated and plotted in the following Tables and Figures.

Table 2

## Ground Water Elevations (in Feet) During Pumpage

November 5, 1981

| WELL                | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| PRODUCTION WELL H-1 | 1030 | 68.0 | 1103 | 68.1 | 1149 | 67.9 | 1158 | 49.4 | 1207 | 49.2 | 1216 | 48.8 | 1225 | 48.6 |      |      |      |      |      |      |      |      |
| PRODUCTION WELL H-2 | 1031 | 68.4 | 1105 | 68.4 | 1157 | 62.9 | 1205 | 62.3 | 1214 | 62.2 | 1223 | 62.5 | 1232 | 61.9 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 1  | 1031 | 69.4 | 1105 | 69.4 | 1155 | 69.4 | 1204 | 69.5 | 1213 | 69.5 | 1222 | 69.5 | 1231 | 69.5 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 2  | 1035 | 68.5 | 1101 | 68.4 | 1152 | 68.5 | 1159 | 68.4 | 1209 | 68.4 | 1217 | 68.4 | 1226 | 68.4 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 3  | 1014 | 69.7 | 1037 | 69.7 | 1112 | 69.8 | 1200 | 69.8 | 1210 | 69.8 | 1223 | 69.8 | 1239 | 69.7 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 4  | 1019 | 69.8 | 1041 | 69.8 | 1117 | 69.8 | 1203 | 69.7 | 1214 | 69.7 | 1227 | 69.7 | 1238 | 69.7 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 5  | 1003 | 68.0 | 1032 | 68.0 | 1106 | 68.0 | 1126 | 68.0 | 1155 | 68.0 | 1206 | 67.9 | 1232 | 67.7 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 6  | 1038 | 67.5 | 1109 | 67.1 | 1154 | 67.4 | 1203 | 67.8 | 1212 | 67.3 | 1220 | 66.9 | 1230 | 66.8 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 7  | 1040 | 67.6 | 1059 | 67.5 | 1153 | 67.6 | 1202 | 67.6 | 1211 | 67.6 | 1219 | 67.6 | 1228 | 67.5 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 8  | 1016 | 68.6 | 1039 | 68.6 | 1115 | 68.6 | 1202 | 68.6 | 1212 | 68.4 | 1225 | 68.3 | 1236 | 68.3 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 9  | 1007 | 69.7 | 1036 | 69.7 | 1110 | 69.7 | 1158 | 69.7 | 1209 | 69.6 | 1229 | 69.6 | 1247 | 69.5 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 10 | 1025 | 74.1 | 1046 | 74.1 | 1120 | 74.0 | 1218 | 74.0 | 1257 | 74.0 | 1430 | 74.0 | 1611 | 74.0 |      |      |      |      |      |      |      |      |

| WELL                | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| PRODUCTION WELL H-1 | 1233 | 48.5 | 1241 | 67.7 | 1250 | 67.8 | 1310 | 67.7 | 1326 | 60.8 | 1340 | 60.6 | 1407 | 61.9 |      |      |      |      |      |      |      |      |
| PRODUCTION WELL H-2 | 1240 | 61.8 | 1248 | 61.8 | 1323 | 67.8 | 1332 | 67.8 | 1346 | 68.0 | 1400 | 64.9 | 1402 | 22.2 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 1  | 1238 | 69.5 | 1247 | 69.5 | 1321 | 69.5 | 1331 | 69.6 | 1345 | 69.8 | 1405 | 70.6 | 1418 | 70.8 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 2  | 1235 | 68.4 | 1243 | 68.4 | 1315 | 68.4 | 1327 | 68.3 | 1341 | 68.3 | 1408 | 68.3 | 1420 | 68.3 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 3  | 1248 | 69.7 | 1302 | 69.7 | 1320 | 69.7 | 1357 | 69.7 | 1410 | 69.7 | 1423 | 69.7 | 1439 | 69.7 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 4  | 1252 | 69.6 | 1306 | 69.6 | 1325 | 69.7 | 1401 | 69.7 | 1408 | 69.6 | 1421 | 69.5 | 1437 | 69.5 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 5  | 1243 | 67.6 | 1311 | 67.5 | 1313 | 67.5 | 1352 | 67.6 | 1443 | 67.4 | 1445 | 67.3 | 1501 | 67.2 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 6  | 1238 | 66.7 | 1246 | 66.9 | 1320 | 66.8 | 1329 | 66.8 | 1344 | 68.9 | 1411 | 66.8 | 1424 | 66.7 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 7  | 1237 | 67.5 | 1244 | 67.5 | 1318 | 67.4 | 1328 | 67.4 | 1342 | 67.5 | 1422 | 67.4 | 1429 | 67.4 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 8  | 1250 | 68.2 | 1304 | 68.2 | 1322 | 68.4 | 1324 | 68.4 | 1359 | 68.4 | 1406 | 68.5 | 1419 | 68.3 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 9  | 1308 | 69.5 | 1318 | 69.6 | 1355 | 69.6 | 1412 | 69.5 | 1425 | 69.5 | 1441 | 69.5 | 1454 | 69.4 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 10 |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |


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Table 2

## Ground Water Elevations (in Feet) During Pumping

November 5, 1981

| WELL                | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV | TIME | ELEV |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| PRODUCTION WELL H-1 | 1419 | 60.8 | 1427 | 60.6 | 1434 | 60.5 | 1441 | 60.4 | 1448 | 60.2 |      |      |
| PRODUCTION WELL H-2 | 1546 | 66.0 |      |      |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 1  | 1425 | 71.1 | 1432 | 71.3 | 1439 | 71.6 | 1447 | 71.8 | 1453 | 72.0 | 1545 | 73.3 |
| OBSERVATION WELL 2  | 1428 | 68.3 | 1435 | 68.3 | 1443 | 68.3 | 1451 | 68.3 | 1456 | 68.3 | 1546 | 68.0 |
| OBSERVATION WELL 3  | 1452 | 69.7 |      |      |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 4  | 1450 | 69.5 | 1458 | 69.5 |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 5  | 1546 | 67.2 |      |      |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 6  | 1439 | 66.5 | 1445 | 66.7 | 1449 | 66.5 | 1458 | 66.4 | 1543 | 66.5 |      |      |
| OBSERVATION WELL 7  | 1437 | 67.5 | 1444 | 67.4 | 1450 | 67.4 | 1457 | 67.4 | 1553 | 67.2 |      |      |
| OBSERVATION WELL 8  | 1435 | 68.1 | 1449 | 68.0 | 1456 | 68.0 | 1606 | 68.2 |      |      |      |      |
| OBSERVATION WELL 9  |      |      |      |      |      |      |      |      |      |      |      |      |
| OBSERVATION WELL 10 |      |      |      |      |      |      |      |      |      |      |      |      |

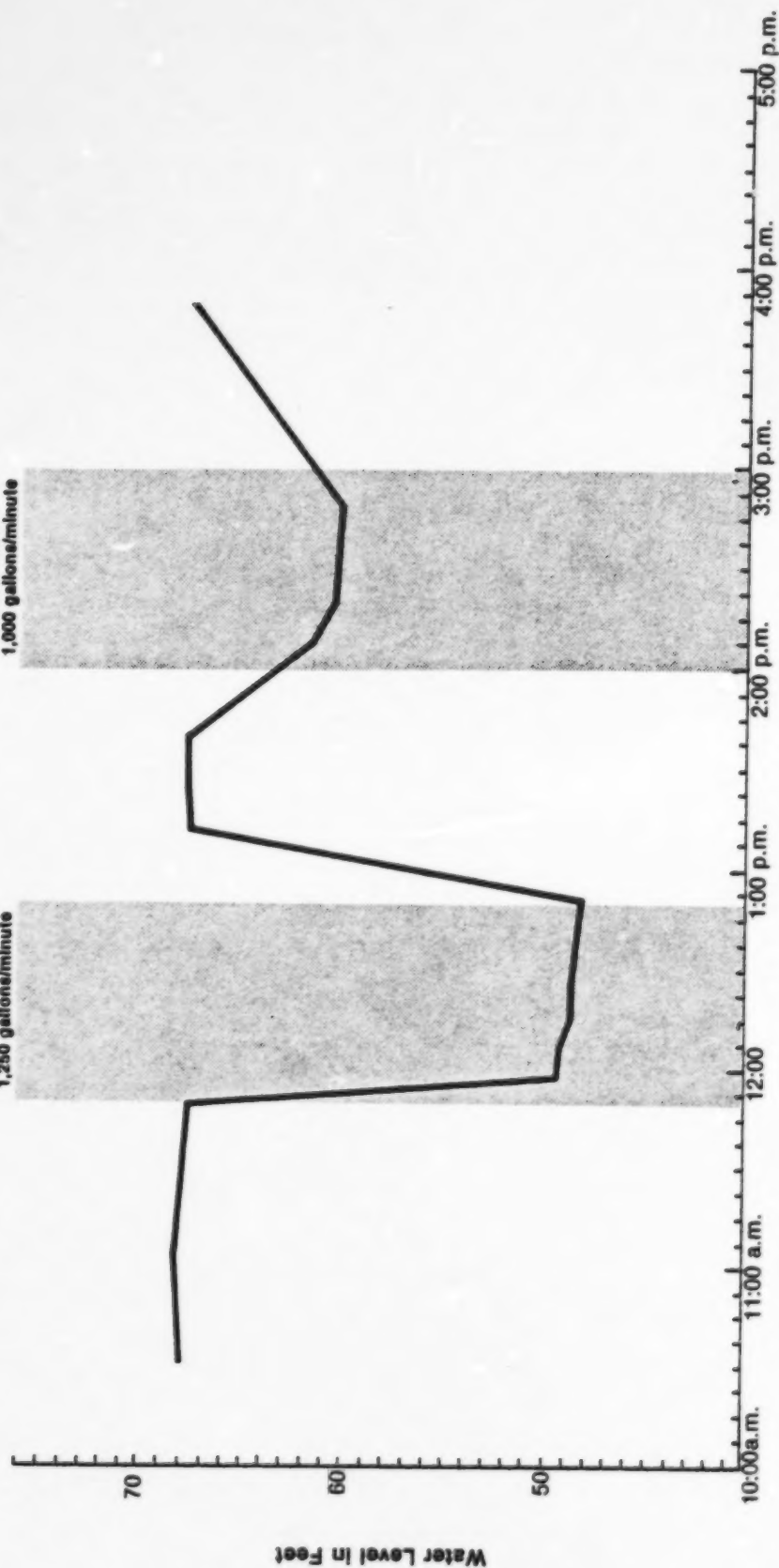
**Production Well H-1**  
Elevation: 99.9 Feet  
November 5, 1981

Pumping Time for  
Production Well H-1  
11:49 a.m. — 12:49 p.m.

Flow Rate  
1,250 gallons/minute

Pumping Time for  
Production Well H-2  
2:00 p.m. — 3:00 p.m.

Flow Rate  
1,000 gallons/minute



Time of Observation

Figure 8

# **Production Well H-2**

Elevation: 98.4 Feet  
November 5, 1981

Pumping Time for  
Production Well H-1  
11:49 a.m. — 12:49 p.m.

Flow Rate  
1,250 gallons/minute

Pumping Time for  
Production Well H-2  
2:00 p.m. — 3:00 p.m.

Flow Rate  
1,000 gallons/minute

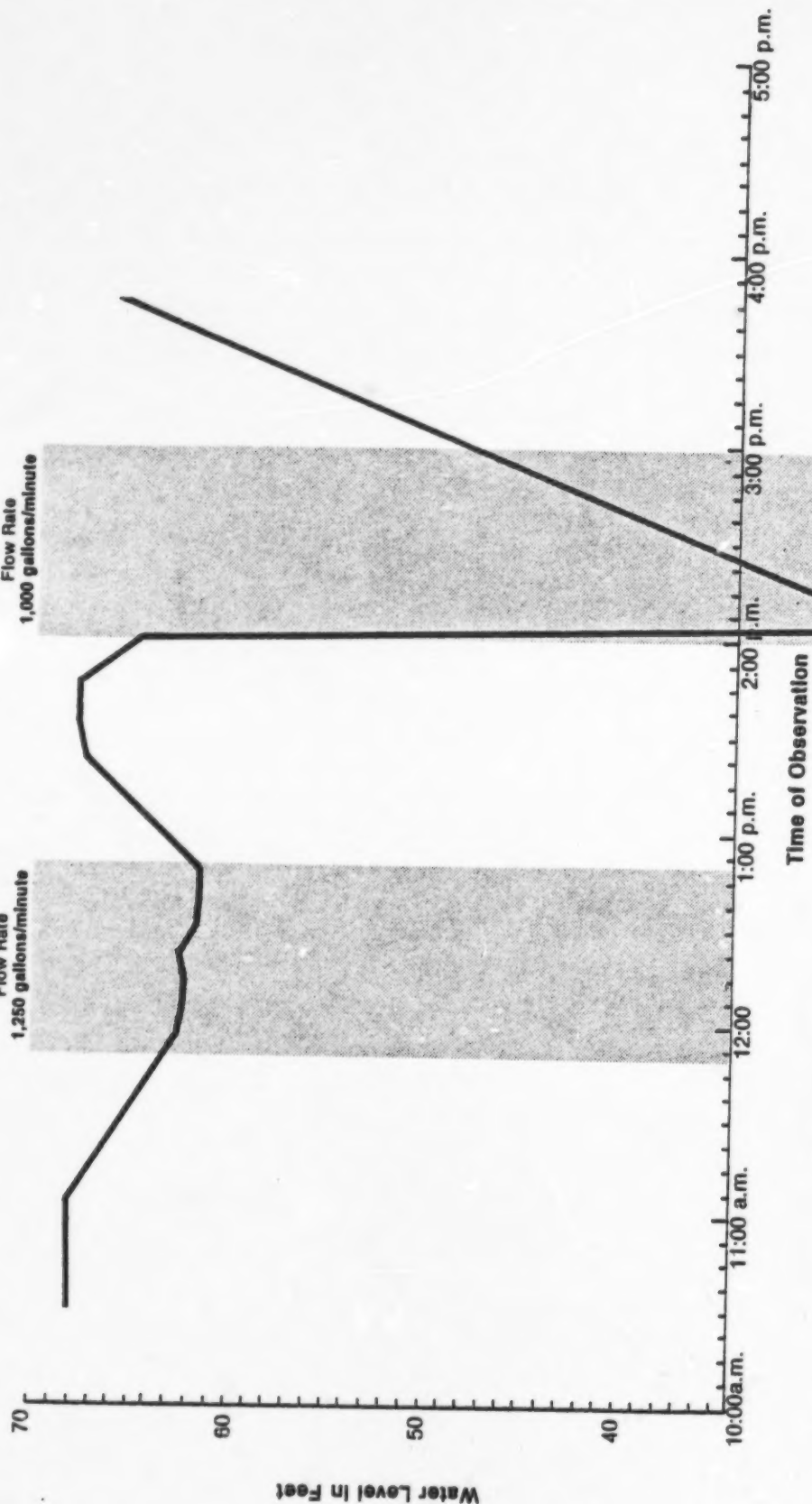


Figure 9

**Observation Well 1**  
Elevation: 99.4 Feet  
November 5, 1981

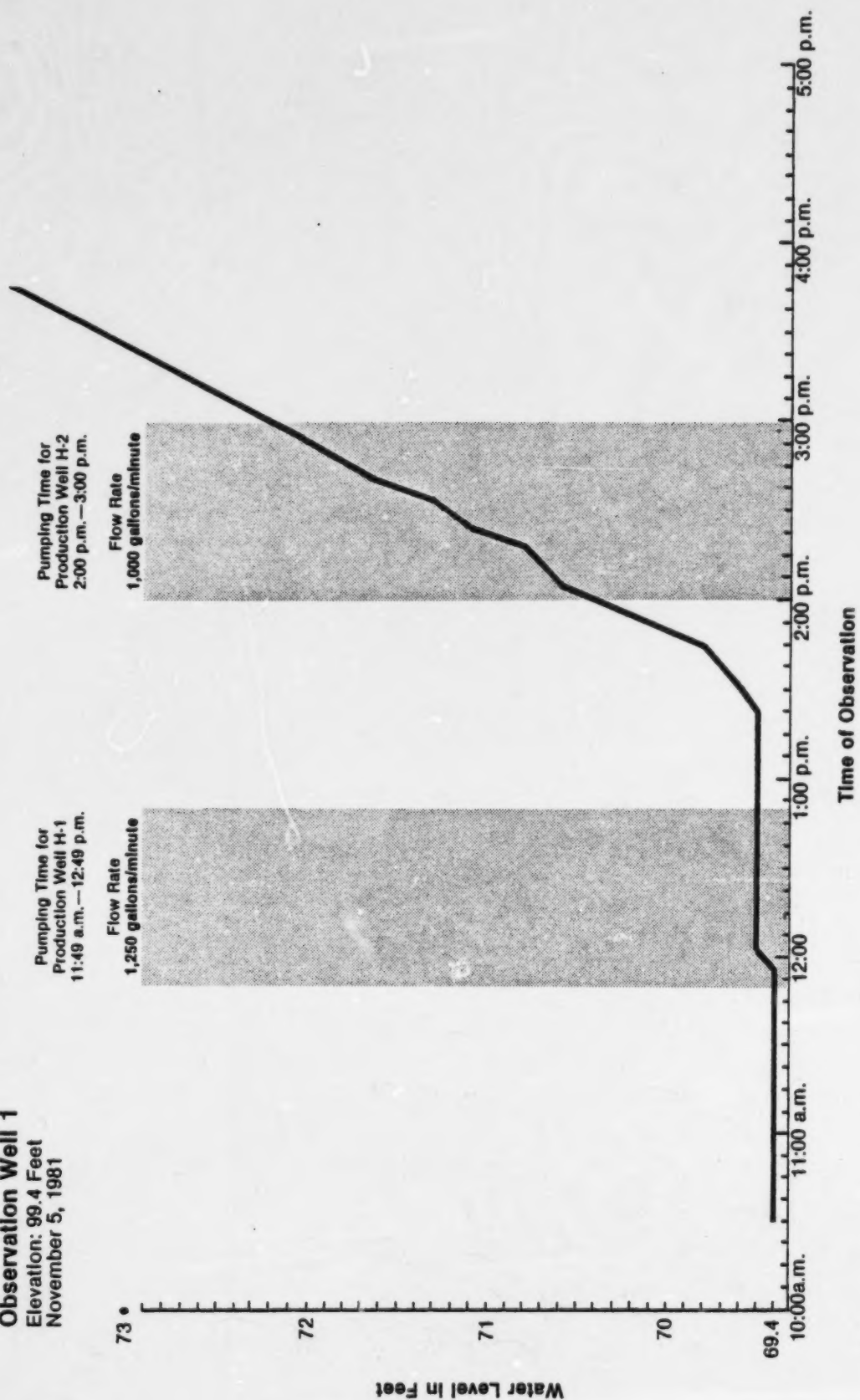


Figure 10

# **Observation Well 2**

Elevation: 100.7 Feet  
November 5, 1981

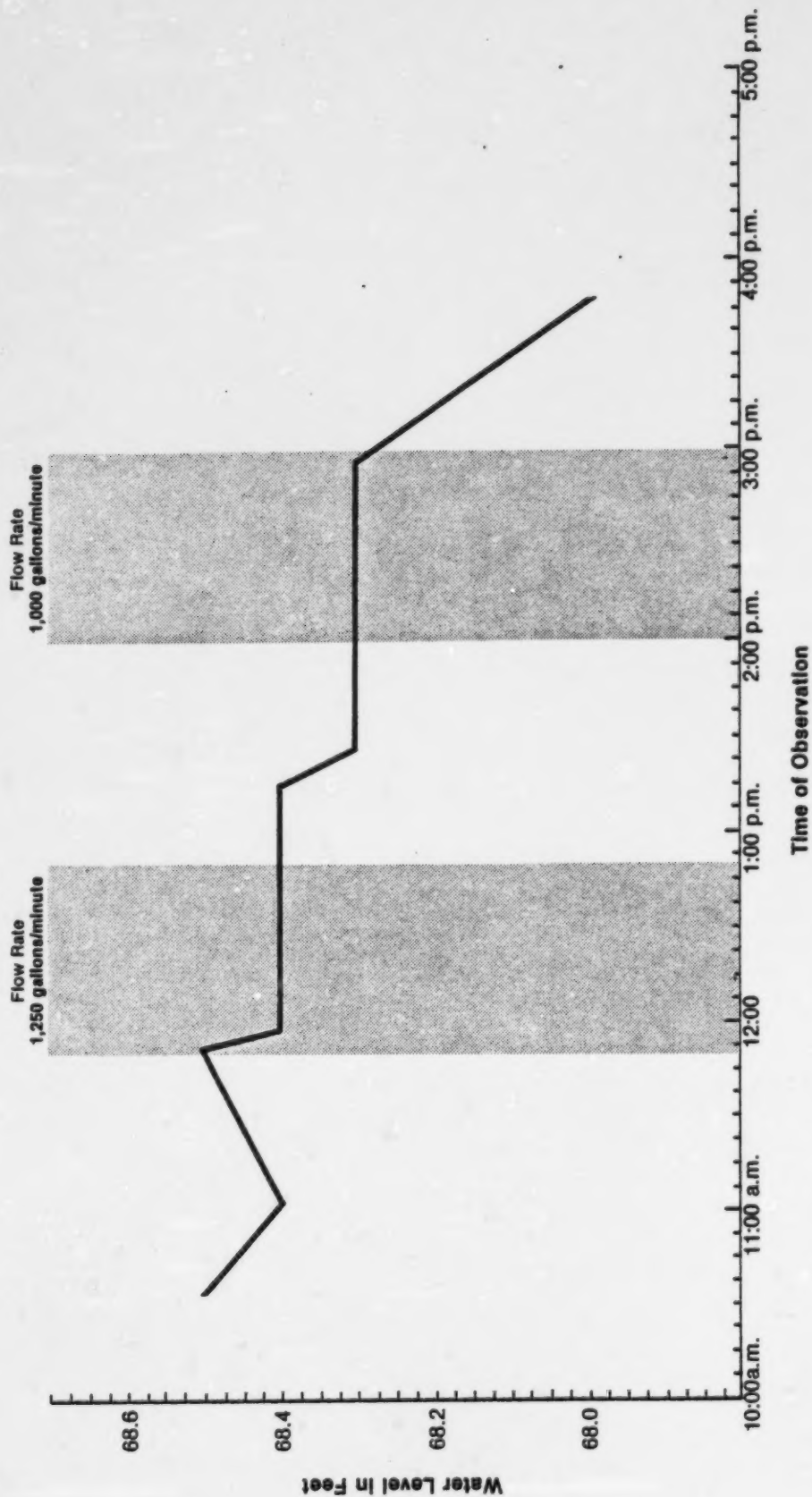


Figure 11

# **Observation Well 3**

Elevation: 99.2 Feet  
November 5, 1981

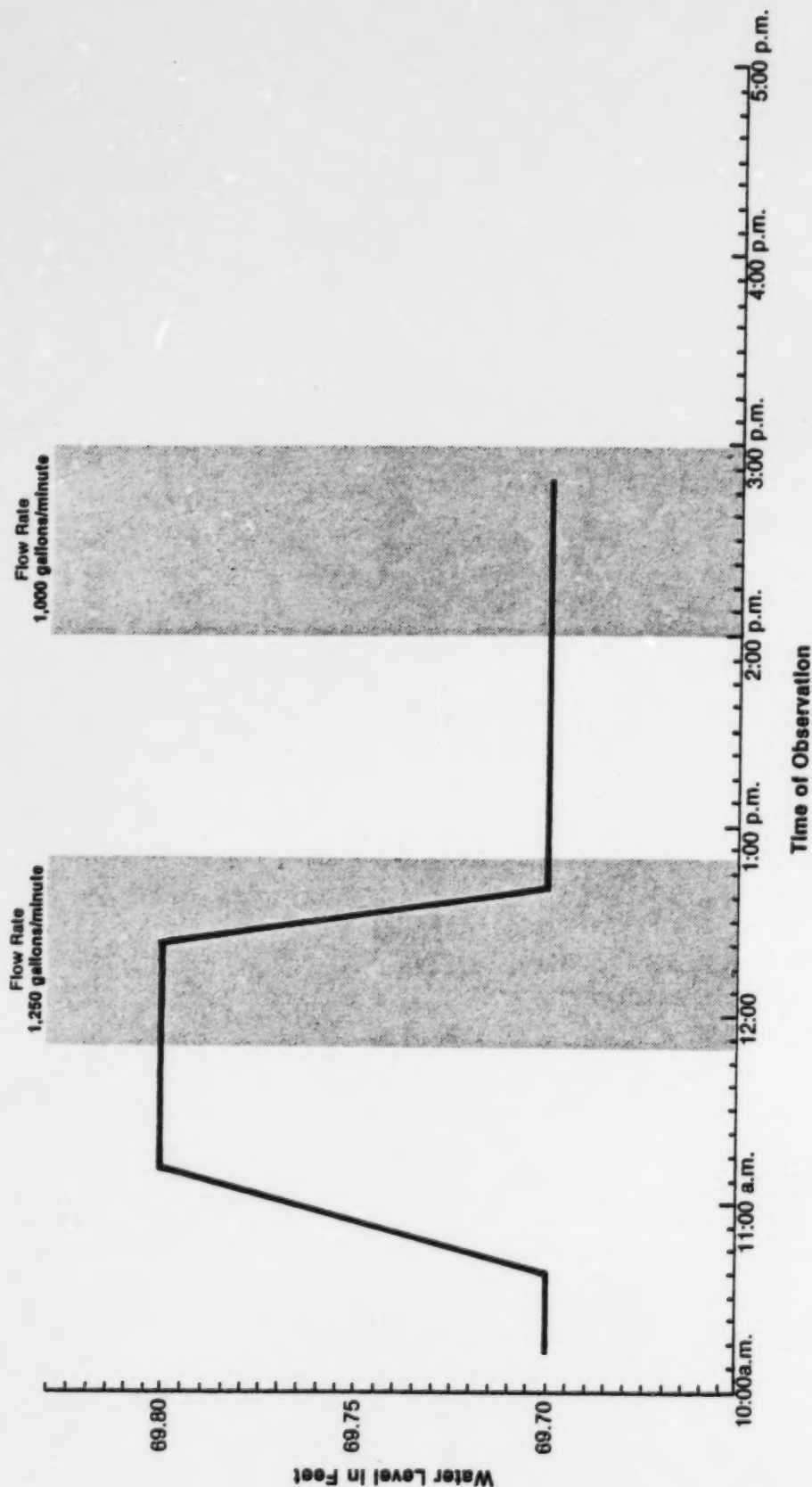
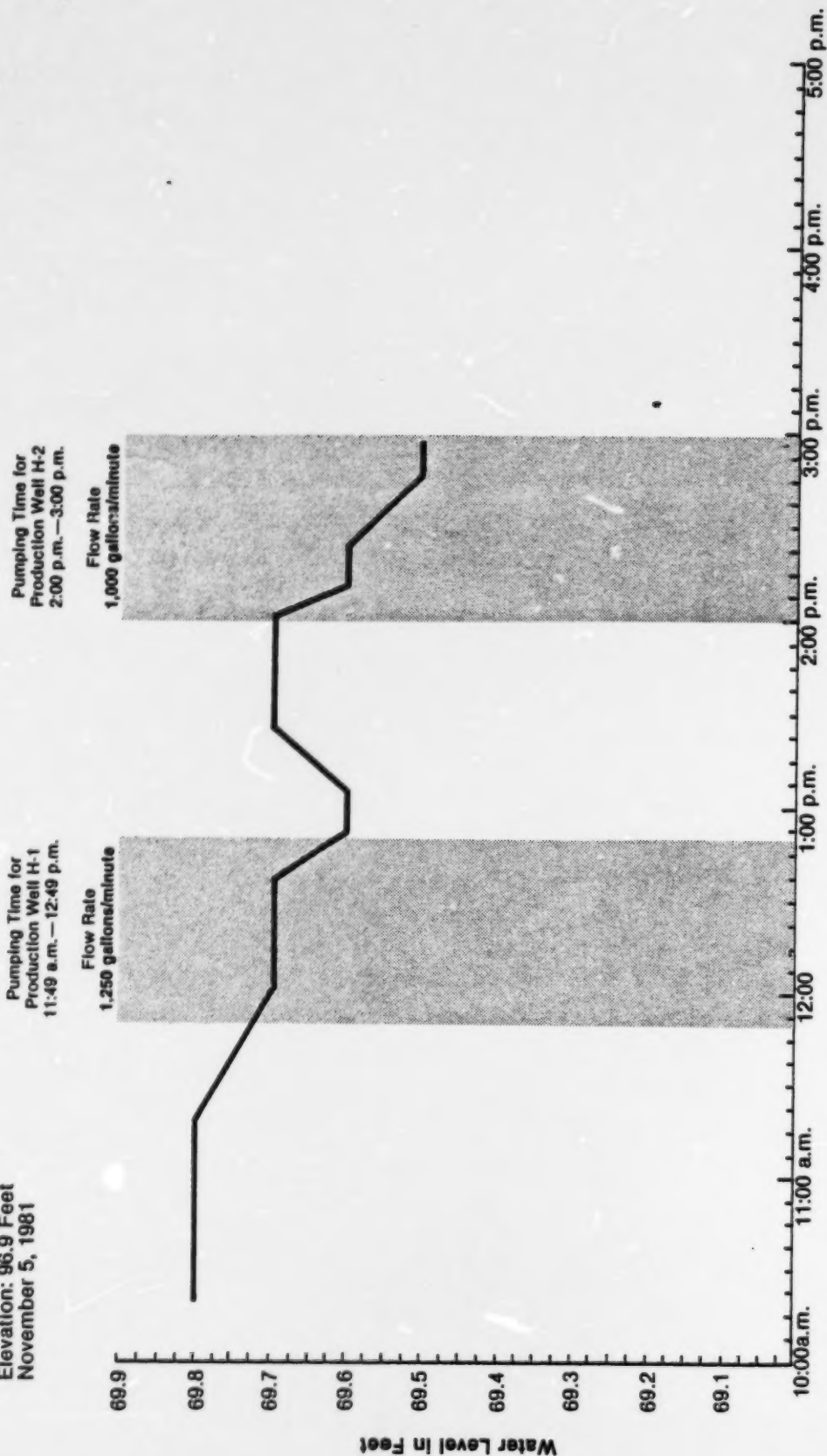


Figure 12

# **Observation Well 4**

Elevation: 96.9 Feet  
November 5, 1981

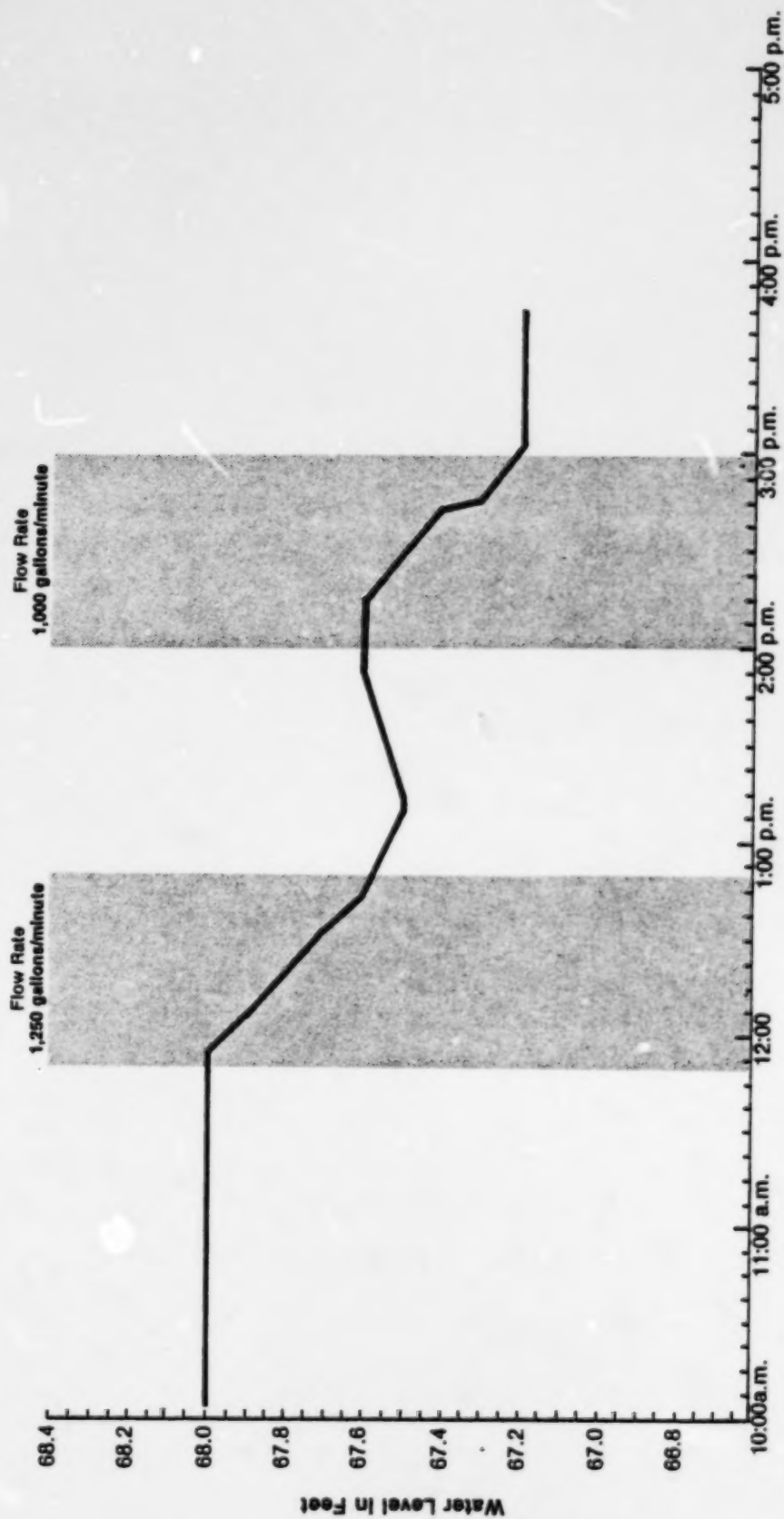


Time of Observation

Figure 13

# **Observation Well 5**

Elevation: 97.7 Feet  
November 5, 1981



Time of Observation  
Figure 14

# **Observation Well 6**

Elevation: 98.7 Feet  
November 5, 1981

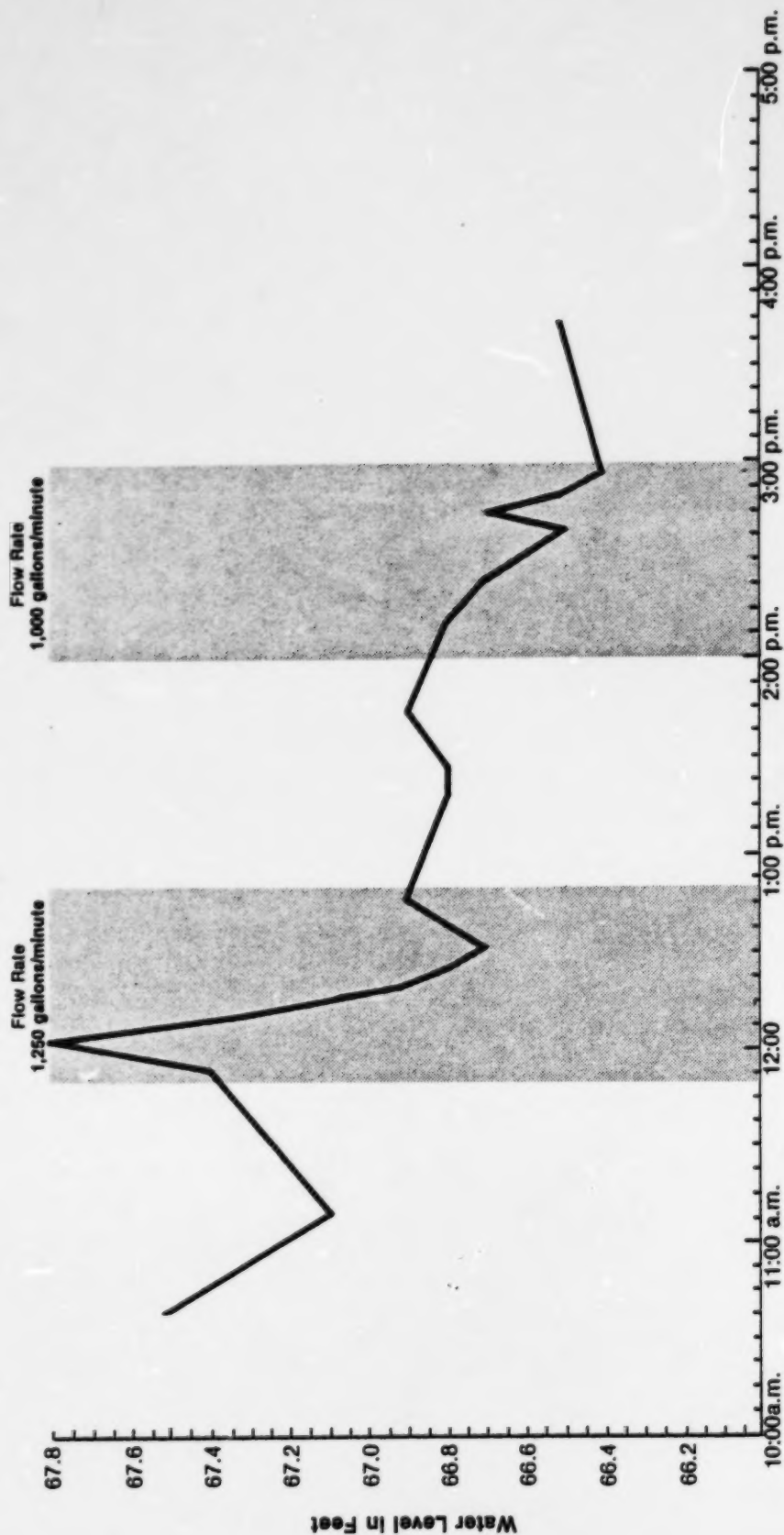


Figure 15

### Observation Well 7

Elevation: 101.1 Feet  
November 5, 1981

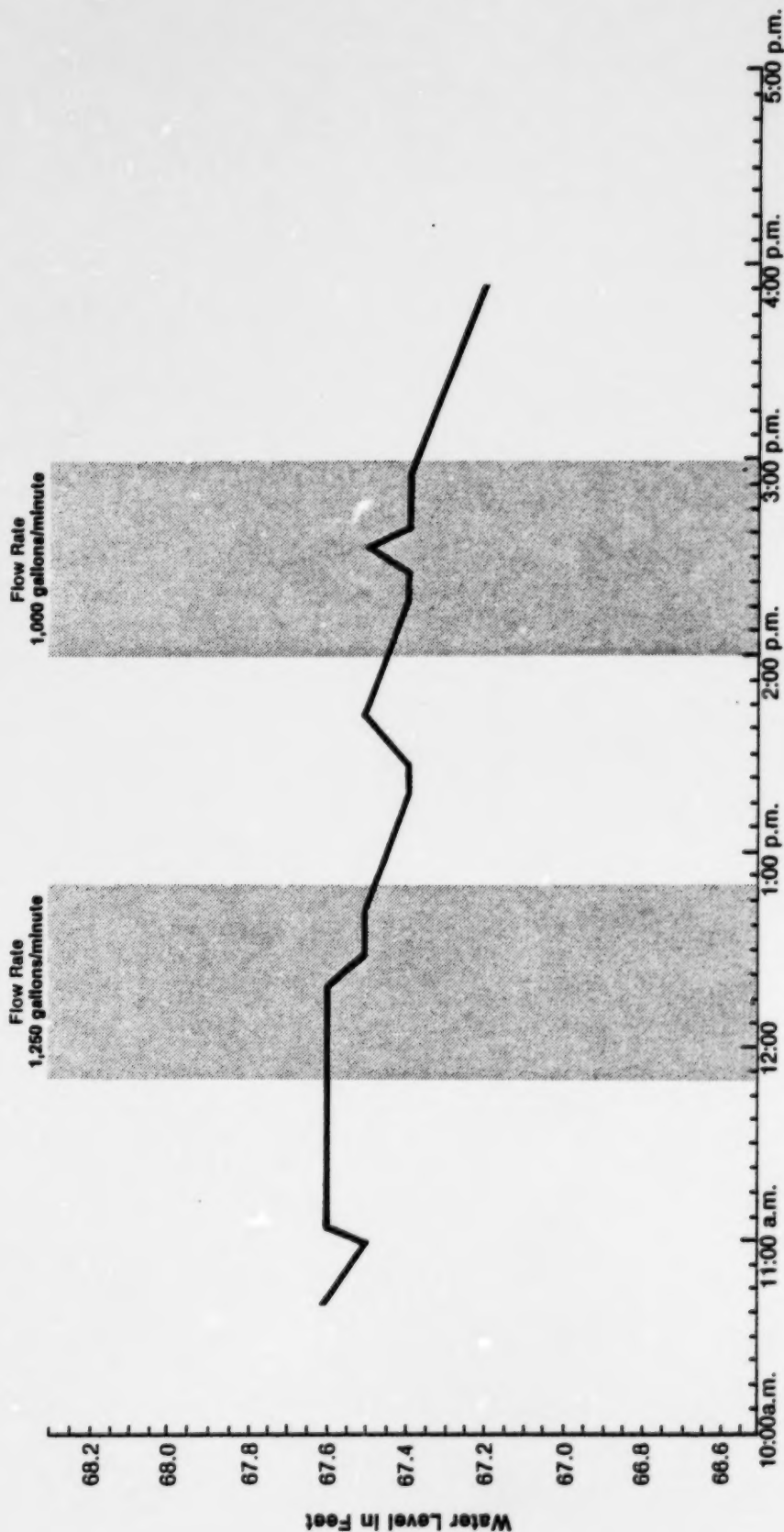


Figure 16

# **Observation Well 3**

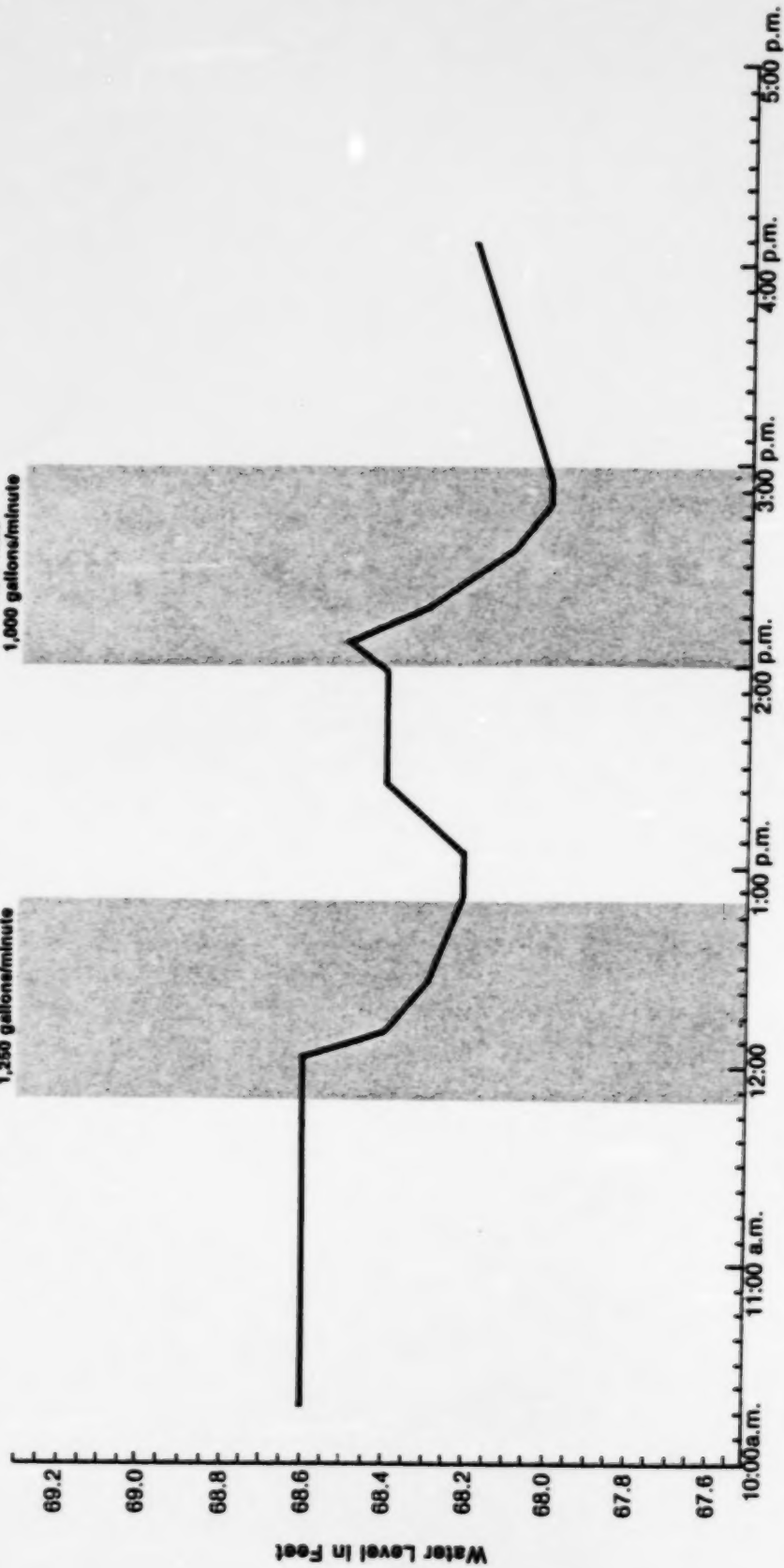
Elevation: 99.3 Feet  
November 5, 1981

Pumping Time for  
Production Well H-1  
11:49 a.m. — 12:49 p.m.

Flow Rate  
1,250 gallons/minute

Pumping Time for  
Production Well H-2  
2:00 p.m. — 3:00 p.m.

Flow Rate  
1,000 gallons/minute



Time of Observation

Figure 17

### Observation Well 9

Elevation: 101.7 Feet  
November 5, 1981

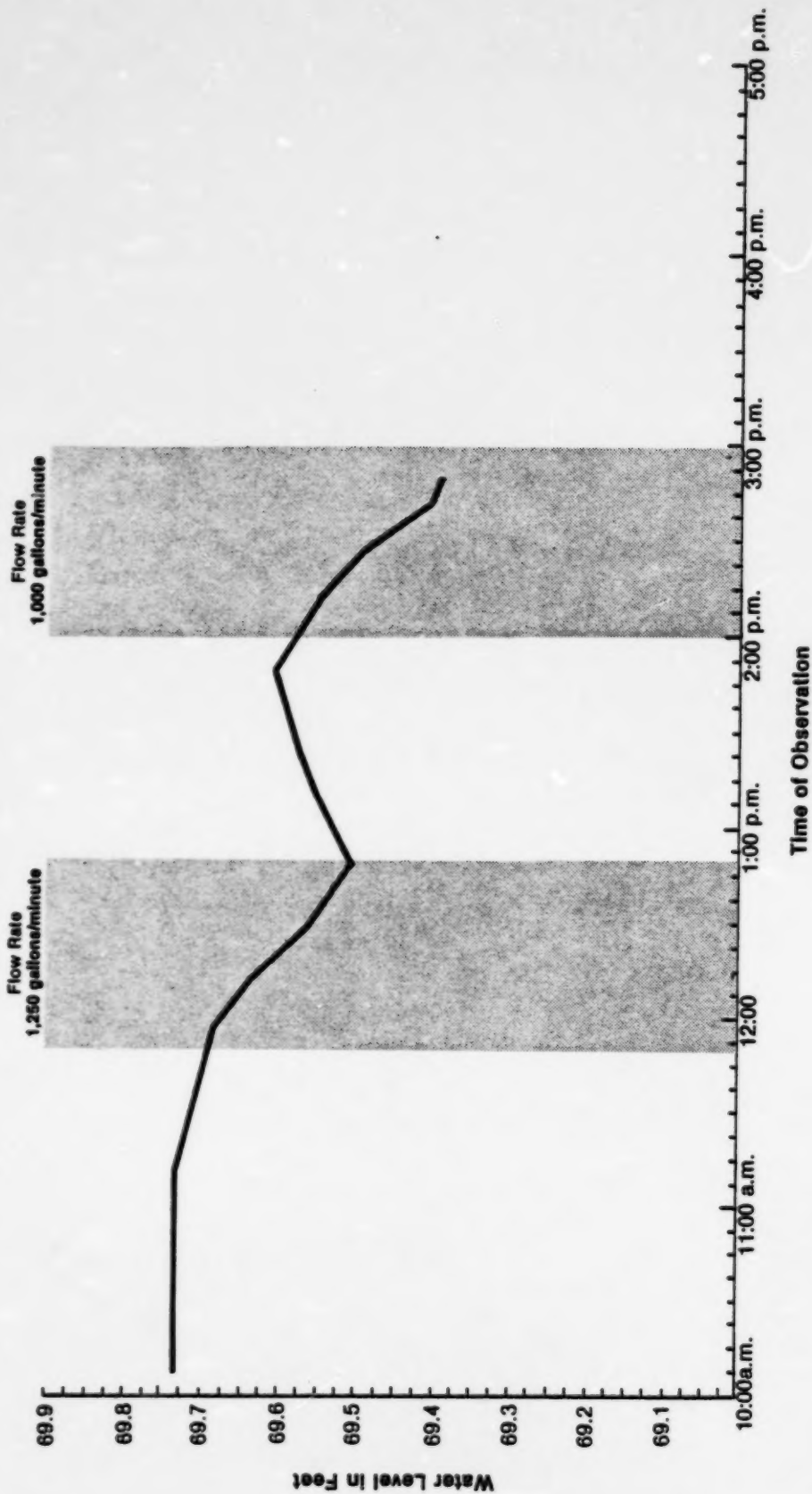


Figure 18

### Observation Well 10

Elevation: 105.0 Feet  
November 5, 1981

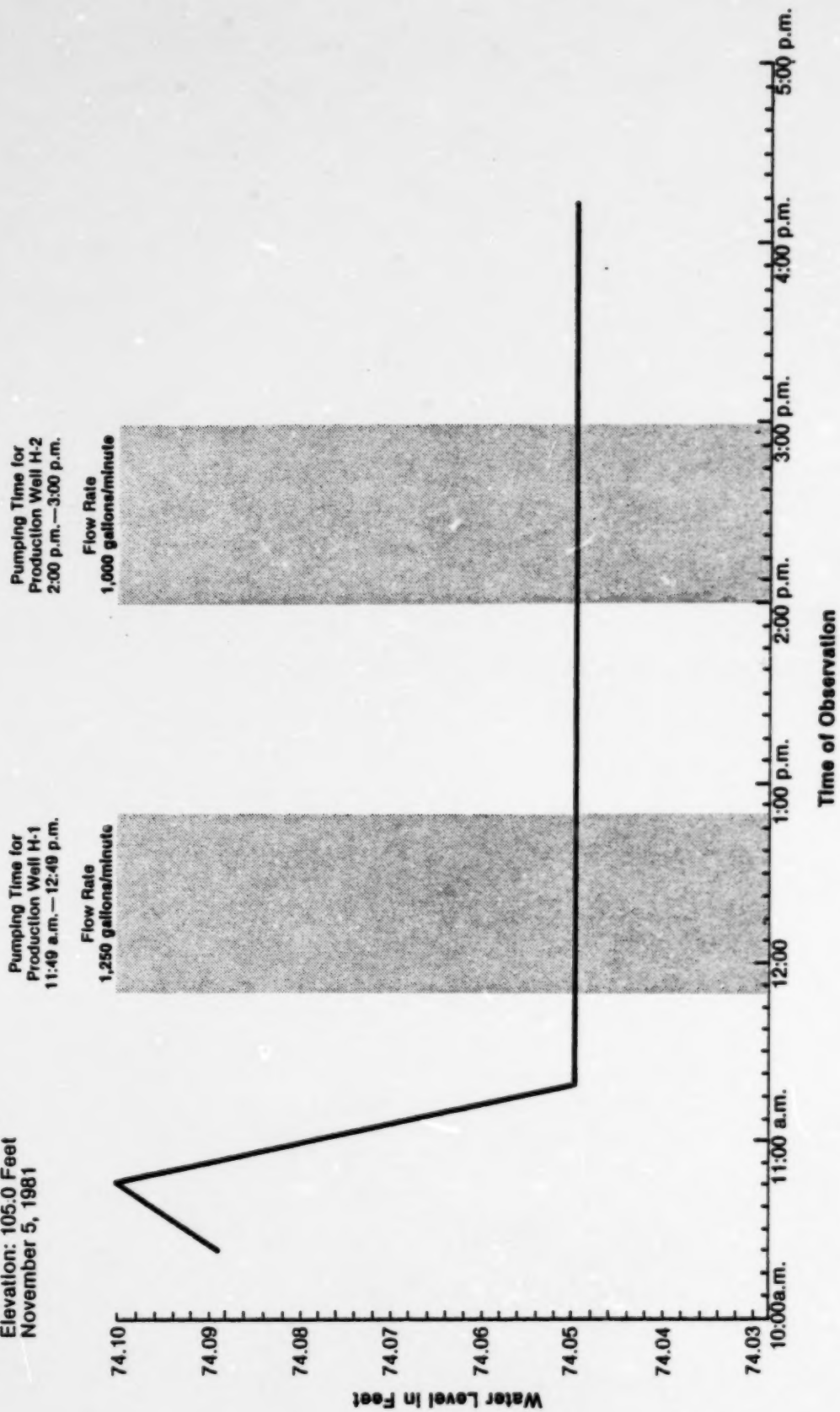


Figure 19

TABLE 3

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

WELL - PRODUCTION WELL H-1  
CONTAMINANT - TETRACHLOROETHYLENE

| SAMPLE # | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
|----------|----------------------------------|----------------------|
| 44-364   | 1                                | 5.6                  |
| 44-365   | 11                               | 23.0                 |
| 44-366   | 23                               | 23.0                 |
| 44-367   | 35                               | 26.0                 |
| 44-368   | 47                               | 29.0                 |
| 44-369   | 60                               | 29.0                 |

TABLE 4

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

WELL - PRODUCTION WELL H-1  
CONTAMINANT - TRICHLOROETHYLENE

| SAMPLE # | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
|----------|----------------------------------|----------------------|
| 44-364   | 1                                | 1.9                  |
| 44-365   | 11                               | 6.6                  |
| 44-366   | 23                               | 3.0                  |
| 44-367   | 35                               | 3.2                  |
| 44-368   | 47                               | 4.2                  |
| 44-369   | 60                               | 3.8                  |

TABLE 5

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

WELL - PRODUCTION WELL H-1

CONTAMINANT - 1,2 TRANS DICHLOROETHYLENE

| SAMPLE # | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
|----------|----------------------------------|----------------------|
| 44-364   | 1                                | 9.8                  |
| 44-365   | 11                               | 34.0                 |
| 44-366   | 23                               | 34.0                 |
| 44-367   | 35                               | 32.0                 |
| 44-368   | 47                               | 37.0                 |
| 44-369   | 60                               | 34.0                 |

TABLE 6

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

WELL - PRODUCTION WELL H-2  
CONTAMINANT - TETRACHLOROETHYLENE

| SAMPLE # | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
|----------|----------------------------------|----------------------|
| 44-370   | 1                                | 80                   |
| 44-371   | 14                               | 128                  |
| 44-372   | 24                               | 136                  |
| 44-373   | 40                               | 138                  |
| 44-374   | 50                               | 131                  |
| 44-375   | 60                               | 133                  |

TABLE 7

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

WELL - PRODUCTION WELL H-2

CONTAMINANT - TRICHLOROETHYLENE

| SAMPLE # | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
|----------|----------------------------------|----------------------|
| 44-370   | 1                                | 18.5                 |
| 44-371   | 14                               | 16.0                 |
| 44-372   | 24                               | 14.0                 |
| 44-373   | 40                               | 15.0                 |
| 44-374   | 50                               | 12.0                 |
| 44-375   | 60                               | 13.0                 |

TABLE 8

CONTAMINANT CONCENTRATION V. S TIME DURING PUMPAGE

| WELL - PRODUCTION WELL H-2               |                                  |                      |
|------------------------------------------|----------------------------------|----------------------|
| CONTAMINANT - 1,2 TRANS DICHLOROETHYLENE |                                  |                      |
| SAMPLE #                                 | TIME (MIN FROM START OF PUMPING) | CONCENTRATION (UG/L) |
| 44-370                                   | 1                                | 120                  |
| 44-371                                   | 14                               | 130                  |
| 44-372                                   | 24                               | 138                  |
| 44-373                                   | 40                               | 138                  |
| 44-374                                   | 50                               | 126                  |
| 44-375                                   | 60                               | 136                  |

Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study

Concentration of Tetrachloroethylene  
Well H-1

November 5, 1981

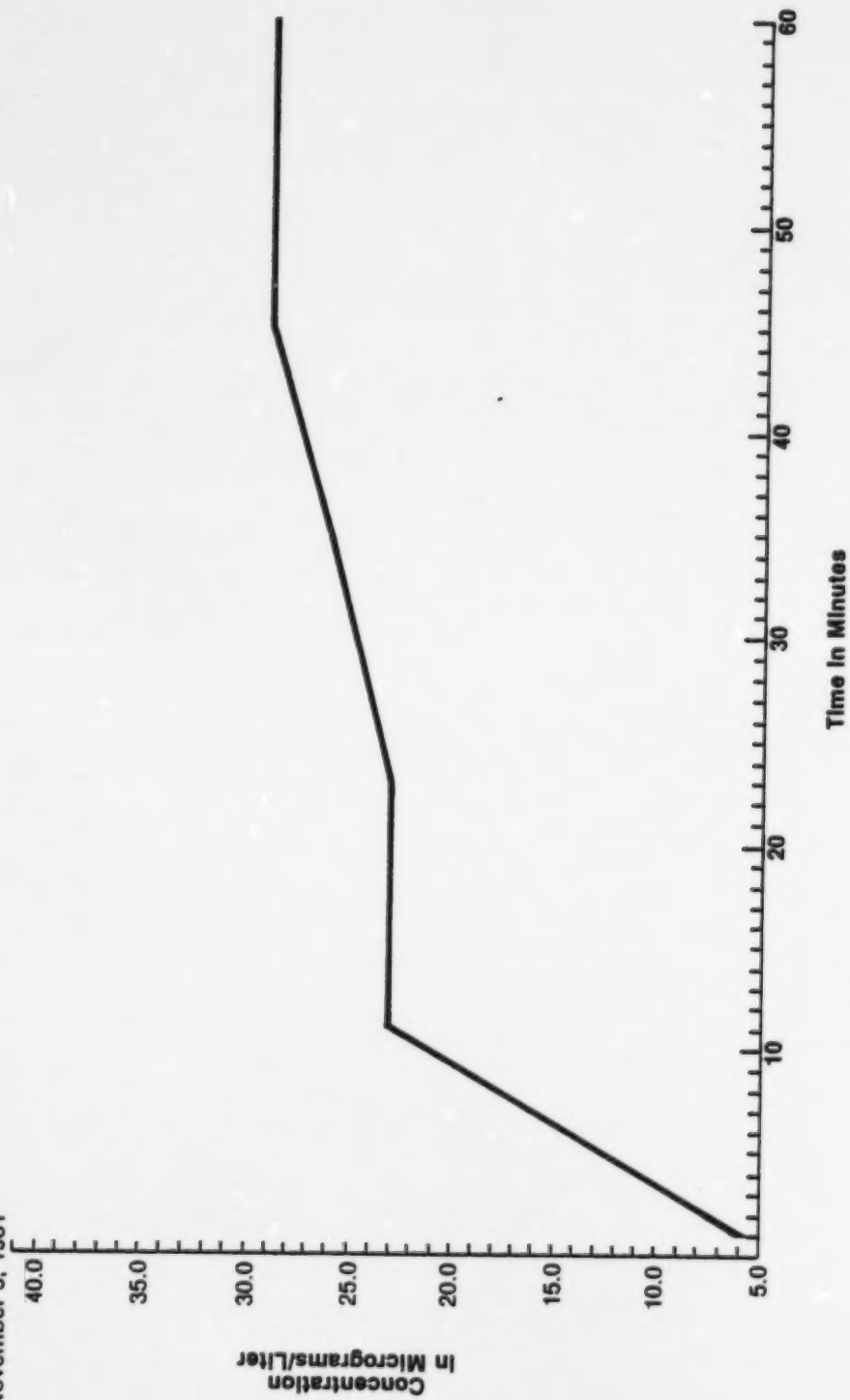
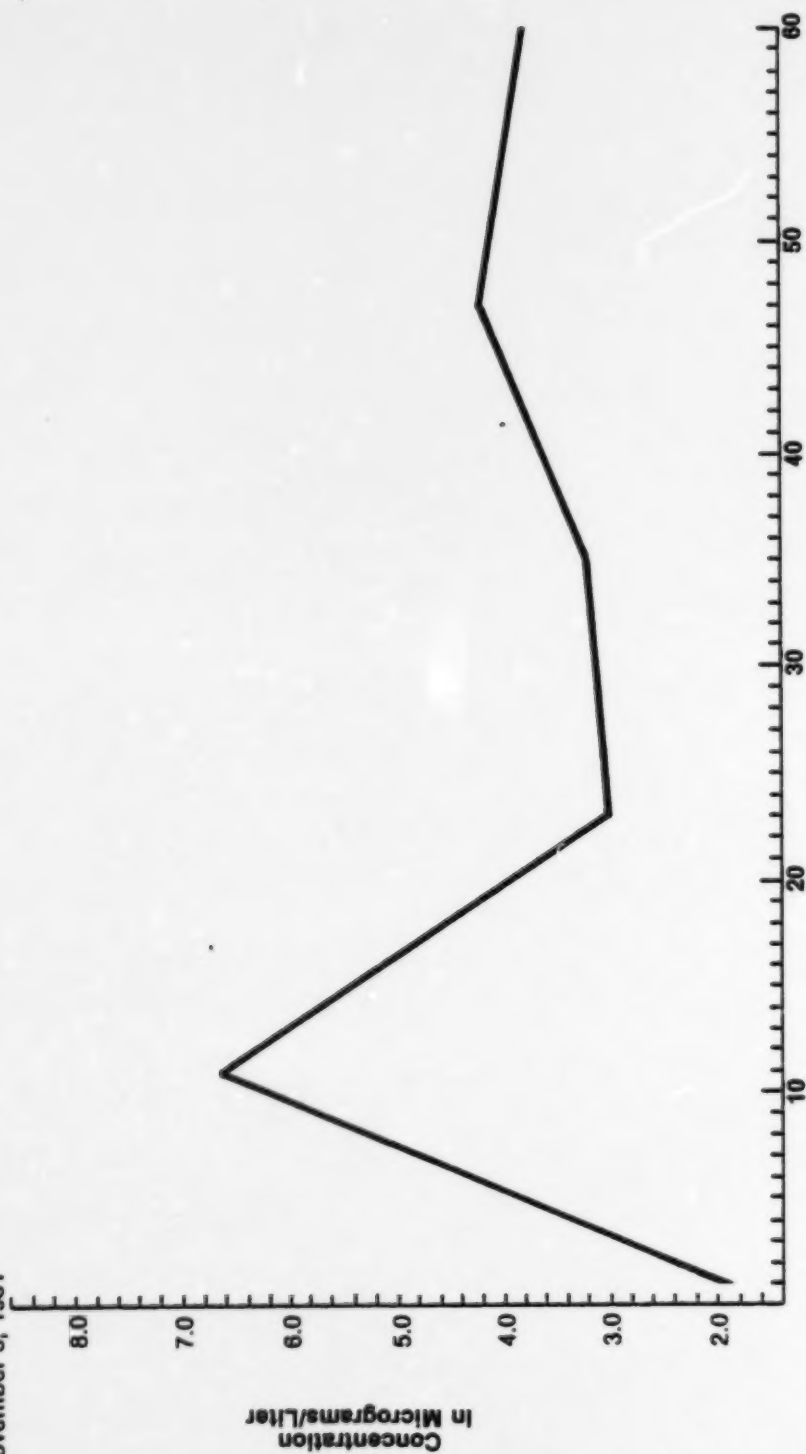


Figure 20

**Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study**

**Concentration of Trichloroethylene  
Well H-1**

**November 5, 1981**



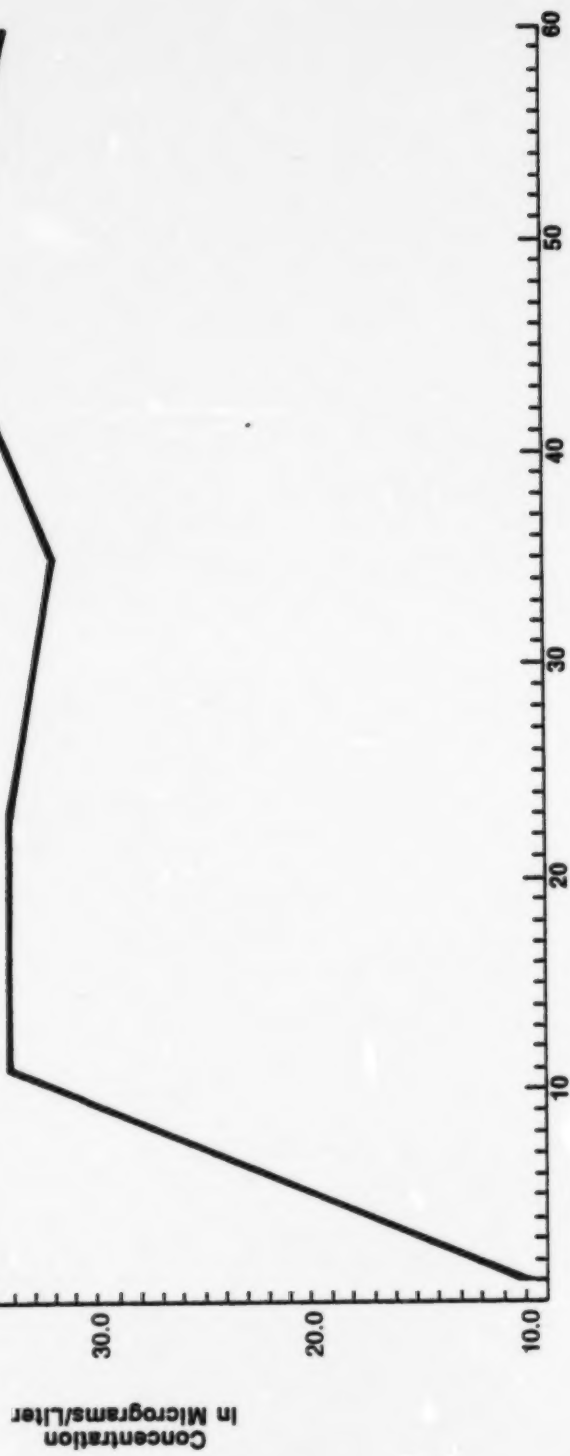
**Time In Minutes**

**Figure 21**

Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study

Concentration of 1,2 (Trans)-Dichloroethylene  
Well H-1

November 5, 1981



Time in Minutes

Figure 22

**Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study**

**Concentration of Tetrachloroethylene  
Well H-2**

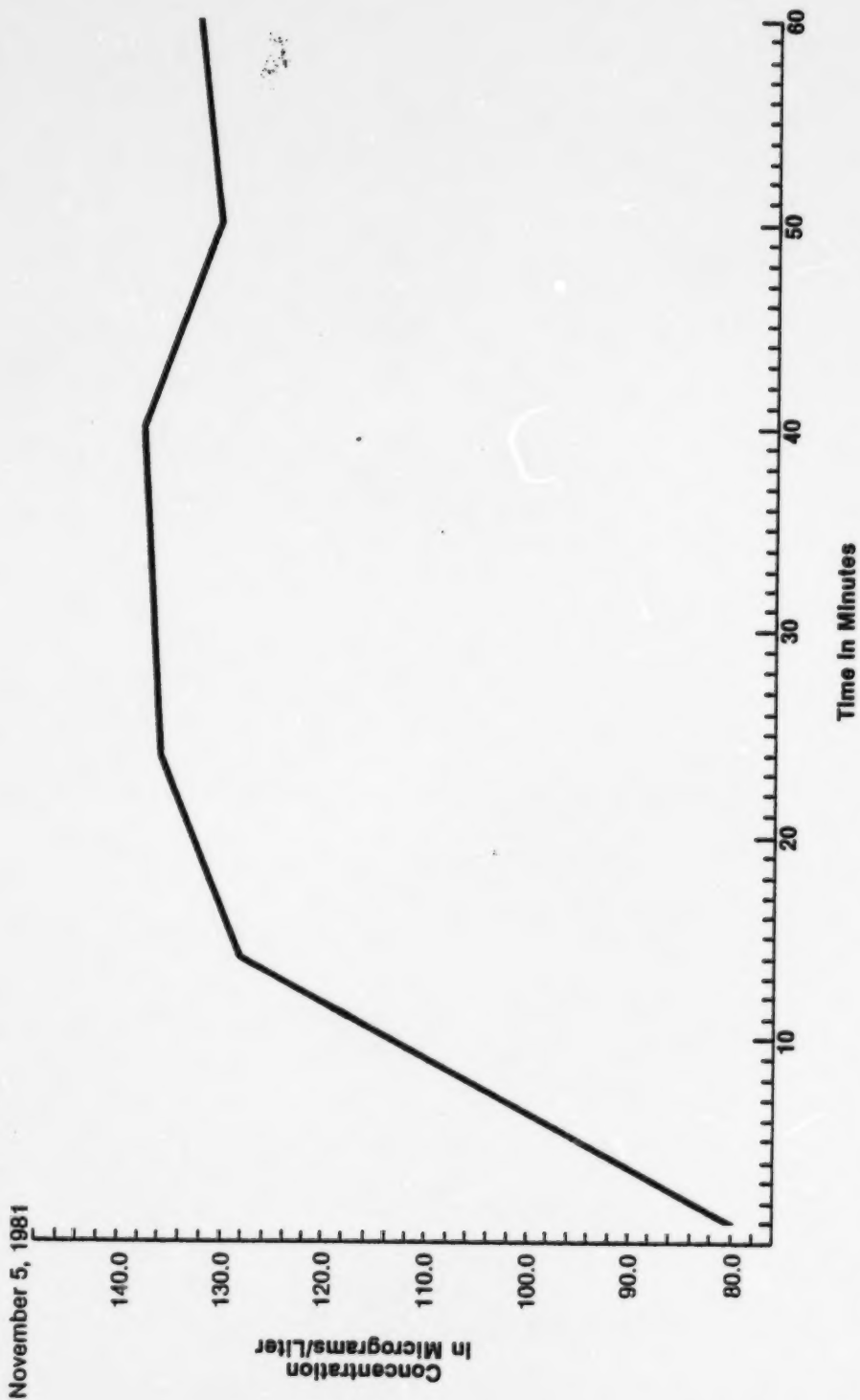


Figure 23

**Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study**

**Concentration of Trichloroethylene  
Well H-2**

November 5, 1981



**Time in Minutes**

**Figure 24**

**Concentration vs. Time During Well Pumpage  
Lakewood Groundwater Study**

**Concentration of 1,2 (Trans)-Dichloroethylene  
Well H-2**

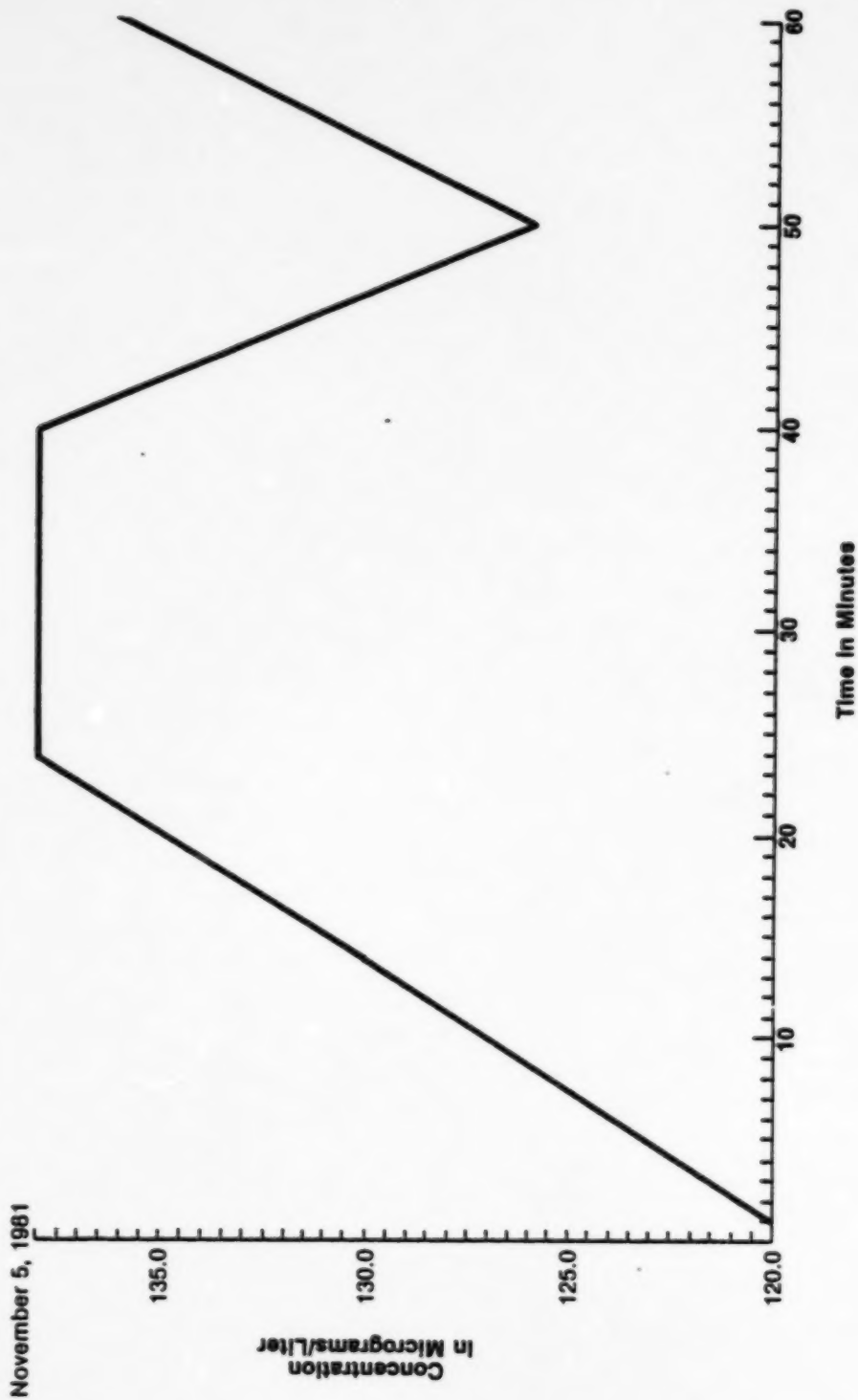


Figure 25

Table 9  
General Geochemical Parameters  
(mg/l)

| WELL                | SAMPLE | HARD | COND <sup>1/</sup> | ALK | TDS | PH <sup>2/</sup> | SO4  | CL  |
|---------------------|--------|------|--------------------|-----|-----|------------------|------|-----|
| OBSERVATION WELL 1  | 46-075 | 79   | 190                | 42  | 225 | 6.2              | 8.4  | 6.6 |
| OBSERVATION WELL 2  | 46-076 | 69   | 143                | 42  | 320 | 6.4              | 4.6  | 2.9 |
| OBSERVATION WELL 3  | 46-077 | 130  | 203                | 78  | 270 | 6.4              | 8.6  | 8.4 |
| OBSERVATION WELL 4  | 46-078 | 154  | 344                | 40  | 330 | 6.2              | 18.0 | 31  |
| OBSERVATION WELL 5  | 46-079 | 252  | 449                | 66  | 410 | 6.5              | 156  | 3.3 |
| OBSERVATION WELL 6  | 46-080 | 96   | 202                | 58  | 350 | 6.4              | 8.4  | 5.4 |
| OBSERVATION WELL 7  | 48-081 | 140  | 160                | 74  | 310 | 6.7              | 6.4  | 5.2 |
| OBSERVATION WELL 8  | 46-082 | 210  | 168                | 78  | 220 | 6.5              | 7.8  | 4.6 |
| OBSERVATION WELL 9  | 46-083 | 99   | 193                | 64  | 300 | 6.1              | 8.4  | 8.6 |
| OBSERVATION WELL 10 | 46-084 | 63   | 162                | 49  | 270 | 6.2              | 19   | 3.4 |
| PRODUCTION WELL H-1 | N. A.  | NA   | NA                 | NA  | NA  | NA               | NA   | NA  |
| PRODUCTION WELL H-2 | 46-086 | 86   | 223                | 77  | 160 | 6.1              | 14   | 13  |

1/ Conductivity is expressed as wmoths.

2/ pH is expressed in pH units.

TABLE 10  
PRIORITY POLLUTANT ORGANIC COMPOUNDS  
DETECTED  
(UG/L)

| WELL        | SAMPLE | DICHLORO | TRI  | TETRA | NAPHTHALENE | PCB 1254 |
|-------------|--------|----------|------|-------|-------------|----------|
| OB WELL 1   | 46-075 | 8.0      | 0.5  | 2.0   | ND          | ND       |
| OB WELL 2   | 46-076 | 0.3      | ND   | 0.2   | ND          | ND       |
| OB WELL 3   | 46-077 | ND       | ND   | ND    | <4.0        | ND       |
| OB WELL 4   | 46-078 | 2.5      | ND   | ND    | ND          | ND       |
| OB WELL 5   | 46-079 | ND       | ND   | ND    | ND          | ND       |
| OB WELL 6   | 46-080 | 14.0     | 1.3  | 2.6   | ND          | ND       |
| OB WELL 7   | 46-081 | ND       | ND   | 5.1   | <4.0        | 0.130    |
| OB WELL 8   | 46-082 | ND       | ND   | ND    | ND          | ND       |
| OB WELL 9   | 46-083 | ND       | ND   | ND    | ND          | ND       |
| OB WELL 10  | 46-084 | ND       | ND   | ND    | ND          | ND       |
| PR WELL H-1 | 46-085 | 9.0      | 0.3  | 5.0   | NA          | NA       |
| PR WELL H-2 | 46-086 | 127.0    | 19.0 | 111.0 | NA          | NA       |

ND --- NOT DETECTED  
NA --- NOT ANALYZED

### 5.3 Discussion

The observation wells provided data concerning the interconnection between the upper and lower aquifers. Clearly, the two zones are slightly interconnected and it is reasonable to expect that vertical pathway of high permeability is significantly lower than horizontal. The hypothesis that the annular gravel around H-2 could provide a vertical pathway for contaminant migration remains viable. Chemical analysis of the ground water from the observation wells indicates that the target contaminants (1, 2 (trans) Dichloroethylene, Trichloroethylene and Tetrachloroethylene) are present in wells immediately adjacent to H-2. The concentrations are significantly lower than are present in H-2 during static or pumped conditions.

It is possible that these materials are present in the aquifer, between 35 and 90 ft. moving with the ground water through zones of higher permeability.

Since a hydraulic interconnection has been demonstrated, the background water chemistry becomes significant. If the waters are similar geochemically, it is likely that they have a similar source and occur as a common ground water regime. The study generated data concerning the general chemical nature of the ground water in observation wells 1-10 and from the deeper water in H-2. Analyses seemed to exhibit significant variation in the parameters analyzed. No clear trend was obvious; hence the data was analyzed statistically. Using the Biomedical Computer Programs, P-series, 1979, a cluster analysis was performed. The program formed clusters of analytical data based on one of four distance measures. These distances are the Euclidean distance ( $L_2$ ) the square root of the sum of the squares of the difference between the values of the variables for two cases); the  $L_p$  distance (the sum of the  $p$ th power of the absolute difference); chi-square or phi-square (both measure the difference of frequencies in two cases).

Initially each case was considered a unique cluster. The program, by a series of steps, amalgamates two clusters having the shortest distance between them, forming a new, single cluster. This process of combining clusters continue until all the cases are combined into a single cluster. The data so obtained is presented in Figure 26. This figure shows that the data tends to amalgamate into two unique clusters. One cluster is formed by the data from observation wells 1, 2, 3, 4, 6, 7, 8, 9, 10, and H-2. The other cluster is the data from observation well 5. It would appear that the ground water in observation well 5 has a longer residence, perhaps representing a zone of low velocity or "stagnation" (of flow) in the regional flow network.

Chemical analyses for organic priority pollutants show the presence of Trace Naphtaline in observation wells 3 and 7. Also, in observation well 7, PCB 1254 has been identified. These are likely due to local sources in the immediate vicinity of the wells. The priority metal analysis (Table 13) indicates that distinctive geochemical differences do exist between the observation wells and the production zone of this aquifer. Based upon this information, and the pump test results, the lower aquifer appears to have a higher transmissivity than the upper zone. It should also be noted, the upper aquifer does not meet drinking water standards based on numerous violations of heavy metal standards.

#### 6.0 Conclusions and Recommendations

It is concluded from this investigation that the shallow zone of the aquifer serving Lakewood H-1 and 2 is not the source of contaminants reaching the lower, production zone. It is reasonable to assume that the principle contaminants, in H-1 and 2, are not the result of disposal or spillage in the recent past at or near the site. The hypothesis that these contaminants are migrating vertically through the gravel around H-2 remains a possibility. It is possible that a deeper zone, between 35 and 90 feet, beneath the surface is significantly contaminated. It is therefore recommended that an additional well be constructed near H-2 to a depth as required in order to establish or rule out this "intermediate zone" of contamination. Depth selection would necessarily be based on field data obtained by careful sampling during drilling. The OVA-128 should be used to analyze bailed water during drilling. Such a well would be constructed by cable tool, installing casing continuously and sampling at a very close interval, perhaps 1 foot. If a "hot" zone of contamination is encountered, the drilling would stop and slot cut at depth using a Mills knife. Extreme care in order not to provide an additional pathway of migration into the production zone would have to be present during this drilling program.

If it is determined that the source of contaminants is desired, additional wells completed deeper in the formation are required. The depth selection would be based on the results of the single additional well. From the information obtained in this study it is reasonable to assume that without removal of the source, the contamination of Lakewood H-1 and H-2 will continue for an unknown period of time. The problem is serious enough to warrant taking the two wells out of service indefinitely or beginning treatment by advanced technology for removal of these compounds.

We recommend:

- 1) A survey should be initiated at Clover Creek for the target compounds.

- 2) the construction of a deeper well near H-2 to evaluate the presence of these compounds between a depth of 35 and 90 feet
- 3) The construction of 8-10 additional wells, screened in the zone located in 2 above. These wells would be best constructed interactively making use of the OVA and HNU. With these wells, a better data base will be established for tracking this contamination to its source.

TABLE 13  
Priority Metals Analysis

(ug/l)

| WELL                | SB | AS  | BE   | CD   | CR  | CU  | PB  | HG   | NI  | SE   | AG   | TL   | ZN   |
|---------------------|----|-----|------|------|-----|-----|-----|------|-----|------|------|------|------|
| OBSERVATION WELL 1  | <2 | 211 | 3.9  | 1.2  | 194 | 328 | 72  | 1.4  | 510 | <2.5 | 2.1  | <1.0 | 690  |
| OBSERVATION WELL 2  | <2 | 9   | <0.1 | <0.2 | 6   | 14  | 19  | 0.15 | 38  | <2.5 | <0.3 | <1.0 | 70   |
| OBSERVATION WELL 3  | <2 | 500 | 6.6  | 1.8  | 250 | 448 | 338 | 1.4  | 900 | <2.5 | 2.3  | <1.0 | 70   |
| OBSERVATION WELL 4  | <2 | 244 | 4.2  | 1.0  | 159 | 280 | 154 | 0.6  | 535 | <2.5 | 2.3  | <1.0 | 650  |
| OBSERVATION WELL 5  | <2 | 69  | 2.1  | 0.4  | 69  | 120 | 132 | 0.3  | 165 | <2.5 | <0.3 | <1.0 | 260  |
| OBSERVATION WELL 6  | <2 | 44  | 1.7  | 0.5  | 19  | 84  | 132 | 0.5  | 170 | <2.5 | <0.3 | <1.0 | 210  |
| OBSERVATION WELL 7  | <2 | 111 | 5.6  | 4.3  | 231 | 456 | 220 | 2.7  | 510 | <2.5 | 1.0  | <1.0 | 1110 |
| OBSERVATION WELL 8  | <2 | 178 | 7.0  | 2.0  | 200 | 408 | 176 | 1.5  | 730 | <2.5 | 1.0  | <1.0 | 950  |
| OBSERVATION WELL 9  | <2 | 104 | 2.1  | 0.6  | 28  | 144 | 47  | 0.3  | 413 | <2.5 | 0.3  | <1.0 | 330  |
| OBSERVATION WELL 10 | <2 | 111 | 1.7  | 0.6  | 28  | 96  | 56  | 0.3  | 375 | <2.5 | 0.3  | <1.0 | 220  |
| PRODUCTION WELL H-1 | NA | NA  | NA   | NA   | NA  | NA  | NA  | NA   | NA  | NA   | NA   | NA   | NA   |
| PRODUCTION WELL H-2 | <2 | 7   | <0.1 | <0.2 | 8   | 8   | 62  | 6.0  | 60  | <2.5 | 0.3  | <1.0 | 80   |



BMDP2M PAGE 3  
LAKWOOD GROUNDWATER STUDY

[illegible]

AMALG.  
DISTANCE

|       | * | * | * | *  | * | *  | *  | *  | *  | *  | * |
|-------|---|---|---|----|---|----|----|----|----|----|---|
| 1.924 | I | I | I | I  | I | I  | I  | ++ | I  | I  |   |
| 1.975 | I | I | I | ++ | I | I  |    | I  | I  | I  |   |
| 2.222 | I | I | I |    | I | I  |    | ++ |    |    | I |
| 2.605 | I | I | I | ++ |   | I  |    |    | I  |    | I |
| 2.730 | I | I | I | ++ |   |    |    |    | I  |    |   |
| 2.708 | I | I | I |    |   | ++ | ++ | ++ |    |    | I |
| 2.966 | I | I |   | ++ |   | ++ |    |    |    |    | I |
| 2.961 | I |   |   |    |   | ++ |    |    |    |    | I |
| 3.354 |   |   |   |    |   | ++ |    |    |    |    | I |
| 4.009 |   |   |   |    |   | ++ | ++ | ++ | ++ | ++ |   |

Figure 26

### Convergence and Amalgamation Analysis

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## APPENDIX

- A. PERMISSION FOR DRILLING FORM
- B. WELL LOGS
- C. OVA DATA
- D. WELL LOGS FROM H-1 AND H-2
- E. SITE SAFETY PLAN

## APPENDIX

### Well Logs

Note: All water levels are as of 17 November 1981

#### Observation well #1 -- Date: 10-9-81

- 0'-14' sand and gravels with cobbles, loose. Grain size decrease with depth.
- 14'-17' Generally fine to medium gravels with few cobbles. A smell of solvents was detected around 16'.
- 17'-23' Same as above. There was a heavy smell of solvents around 22'.
- 23'-24' Generally large cobbles, loose.
- 24'-30' Small to medium cobbles.

Boring completed at 30'

Water level after drilling 21.11 ft.

#### Observation Well #2 -- Date 10-12-81

- 0'-15' Coarse sand and gravels with few cobbles, loose.
- 15'-18' Mainly coarse gravel.
- 18'-21' Fine to medium gravels.
- 21'-26' Coarse gravels with few large cobbles.
- 26'-30' Small to medium gravels, loose.
- 30'-35' Same as above with large cobbles.

Boring complete at 35'

Water level after drilling 31.90 feet

Observation Well #3 -- 10-14-81

0'-25' Generally fine to medium sand and gravels, loose.

25'-35' Medium to coarse gravels.

Boring completed at 35'

Water level after drilling 29.05 feet

Observation Well #4 - 10-15-81

0'-13' Sand and gravels, loose. Gravel size generally range from fine to medium with few coarse gravels. There appears to be slight increase in grain size from 10'.

13'-18' Medium to coarse gravels with few cobbles, loose.

18'-28' Same as above with occasional large cobbles.

28'-35' Generally coarse gravels with few cobbles. Grain size increase with depth.

Boring completed at 35'

Water level after drilling 26.75 feet.

Observation Well #5 -- 10-20-81

0'-4' Sand and gravels, loose.

4'-8' Generally fine to medium gravels, loose.

8'-17' Fine gravels with occasional zones of cobbles.

17'-28' Medium to coarse gravels with few boulders, loose. Grain size generally increase with depth.

28'-35' Fine sand and gravels with few cobbles.

Boring completed at 35'

Water level after drilling 29.10 feet

Observation Well #6 -- 10-21-81

- 0'-5' Sandy clay with gravels (fill)
- 5'-9' Sand and gravels, loose. Gravels are generally fine.
- 9'-10' Medium to coarse sand and gravels with few cobbles.
- 10'-35' Coarse gravels and cobbles. Grain size increase with depth.

Boring completed at 35'

Water level after drilling 30.90 feet.

Observation Well #7 -- 10-21-81

- 0'-3' Sand and gravels (fill).
- 3'-6' Sand and gravels with few cobbles.
- 6'-18' Generally fine to coarse gravels.
- 18'-29' Medium to coarse gravels with occasional cobbles.
- 29'-35' Sand and gravels with clay lenses.

Boring completed at 35'

Water level after drilling 33.25 feet.

Observation Well #8 -- 10-21-81

- 0'-2' Top soil - dark brown sandy clay.
- 2'-7' Medium to coarse sand and gravels with few cobbles.
- 7'-26' Generally coarse gravels with occasional zones of fine gravels.
- 26'-28' Sand and gravels with few cobbles.
- 28'-35' Coarse gravels with cobbles.

Boring completed at 35'

Water level after drilling 30.35 feet.

Observation Well #9 -- 10-22-81

- 0'-2' Top soil, sandy clay with few gravels.
- 2'-11' Coarse gravels.
- 11'-15' Fine to medium gravels with few cobbles.
- 15'-23' Generally coarse gravels with cobbles, clean and loose.
- 23'-35' Cobbles, loose

Boring completed at 35'

Water level after drilling 31.65 feet.

Observation Well #10 -- 10-22-81

- 0'-4' Gravels.
- 4'-6' Generally medium to coarse sand.
- 6'-15' Sand and gravel.
- 15'-27' Medium to coarse gravels with few cobbles, loose.
- 27'-34' Coarse sand and gravels with cobbles.
- 34'-35' Medium to coarse gravels.

~~Boring~~ Boring completed at 35'

Water level after drilling 30.70 feet.

## APPENDIX

### OVA - Organic Vapor Analyzer Results

Observation Wells 1, 2, 3, and 4. Date: 10-9-81 thru 10-19-81.

Each of the monitoring wells had a varying degree of methane as a contaminant. Only Tetrachloroethylene was positively detected in well number 1.

Observation Wells 3, 4, and 5. Date: 10-20-81.

There was a varying degree of total organics in Well #5, between 15'-30' level. The highest reading was 30 ppm.

- 100 ml. of the 1,1,2 trichloroethylene standard was run with a peak developing at the predicted retention time of 7 minutes.
- 200 ml. of water from well #5 showed no results.
- 200 ml. of water from well #3 showed a peak in the backflush cycle at about 11 minutes. This could indicate the presence of tetrachloroethylene or a substance with a similar molecular weight.
- 200 ml. of water from well #4 showed no results.

Observation wells 6 & 7. Date 10-21-81.

The survey mode was used to "sniff" wells 6 and 7 during well construction. The readings showed very small levels of total organic vapor.

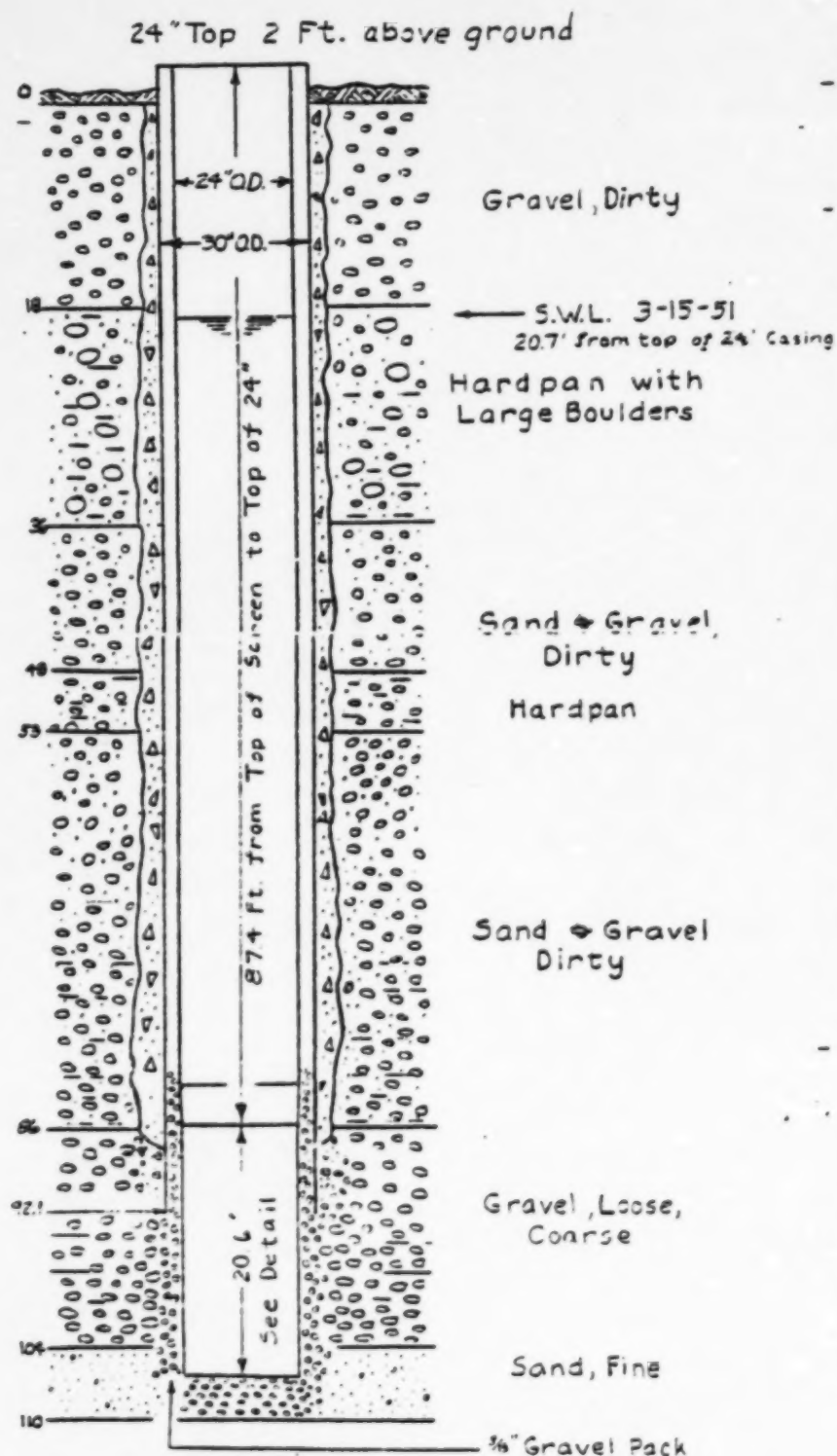
Observation wells 1, 2, 3, 8, and 9. Date 10-22-81.

The survey mode was used to "sniff" #8 and 9 during well construction. The readings indicated less than 5 ppm total organics in the well.

- 200 ml. of water from well #1 showed a small methane peak and a very small peak at 2-3 minutes was noted in the backflush cycle.
- 200 ml. of water from well #2 showed no results.
- 200 ml. of water from well #3 showed a small peak at 11-12 min. which may indicate a low level of tetrachloroethylene or a substance of like molecular weight. Small peaks also noted at 12-13 min. of backflush cycle. Possibly this may merely be "noise" on the strip chart recorder.

Observation Well #4. Date 10-23-81.

- 50 ml. of the trichloroethylene standard was run with a peak developing at the predicted time of 4.5 min.
- 200 ml. of water from well #4 showed a peak at about 3 min. This may indicate presence of dichloroethylene.



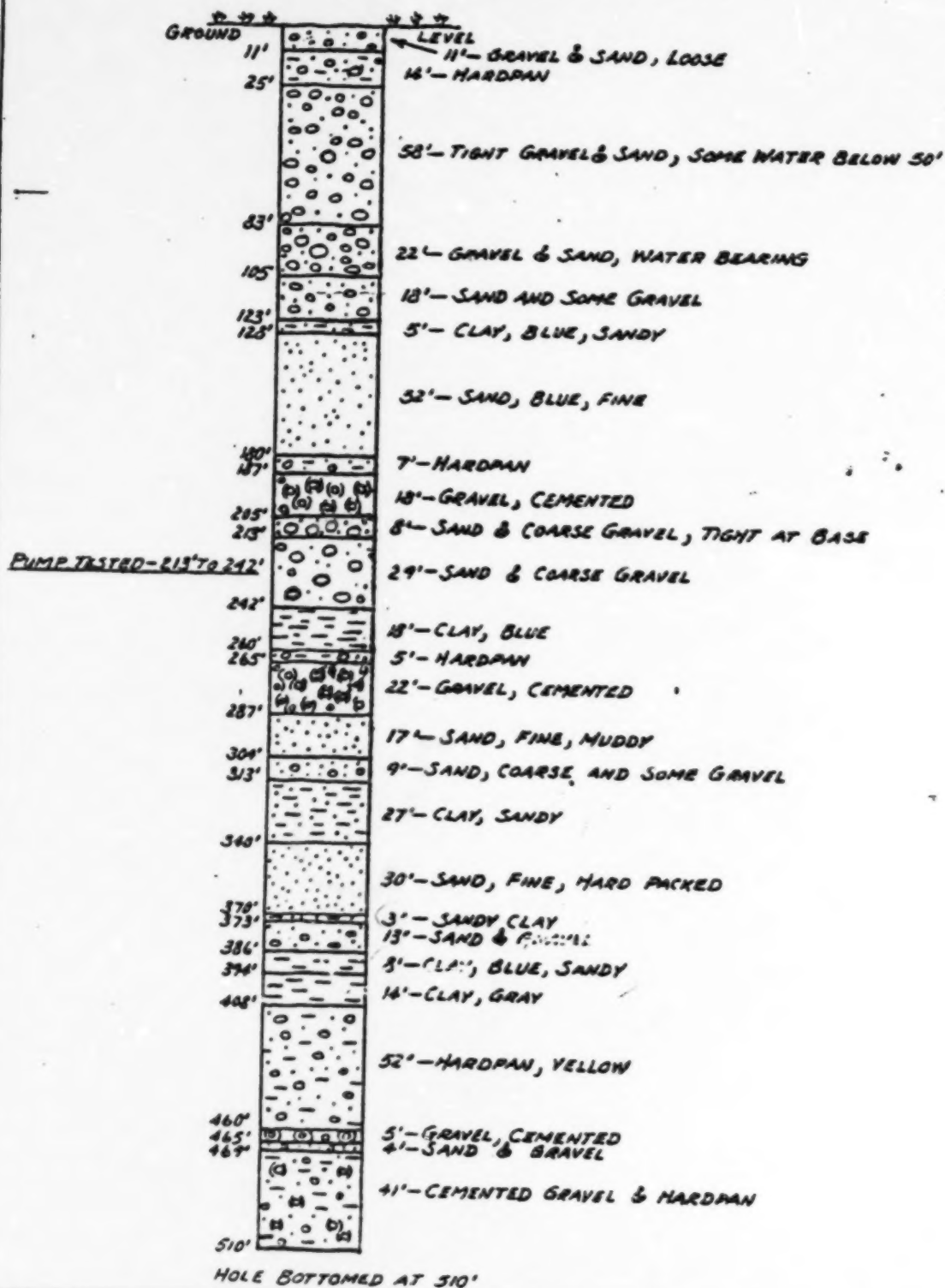
#### WELL DATA

30" & 24" Casing 3/8" Thick

☐ Cement, Gravel & Sand Grout Backfill

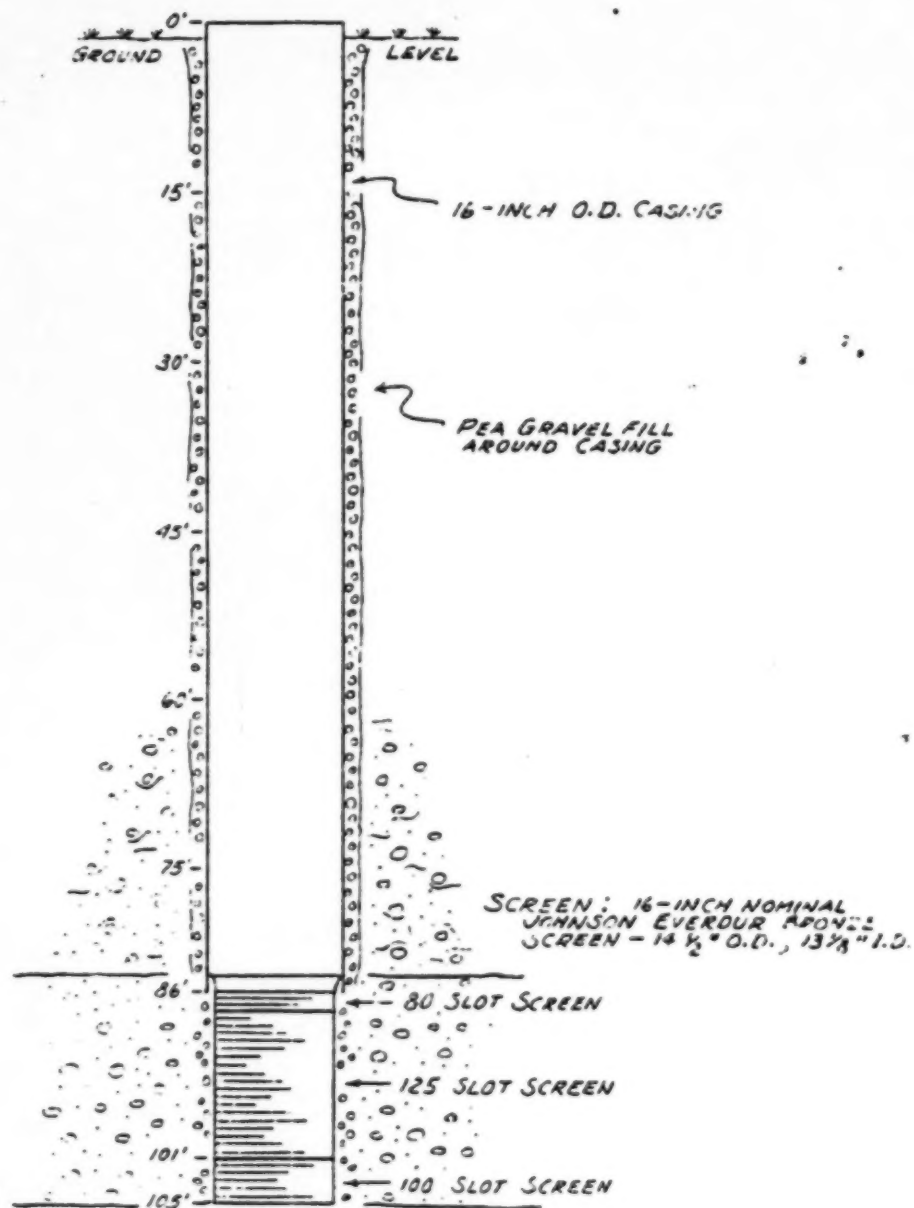
Gravel Backfill from 106' to 110' Below Screen

# TEST WELL NO. 2 AT PONDERS CORNER



|                                                     |                                                                                           |                               |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------------|
| LAKWOOD WATER DISTRICT<br>PIERCE COUNTY, WASHINGTON | ROBINSON AND ROBERTS<br>GROUND WATER GEOLOGISTS<br>TACOMA, WASHINGTON<br>John W. Robinson | SEPT. 24, 1959<br>A-433, H.N. |
| DRILLED BY: L.R. GAUDIO DRILLING CO.                |                                                                                           |                               |

CONSTRUCTION DETAILS  
OF WELL H-2 AT PONDERS CORNER



|                                                      |                                                                                                  |               |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------|
| LAKEWOOD WATER DISTRICT<br>PIERCE COUNTY, WASHINGTON | ROBINSON AND ROBERTS<br>GROUND WATER GEOLOGISTS<br>TACOMA, WASHINGTON<br><i>John W. Robinson</i> | SEPT 24, 1959 |
| DRILLED BY L. R. GAUDIO DRILLING CO.                 |                                                                                                  | A-434, H. N.  |